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A STUDY OF THE NON-LINEARITY VARIABLE IN FILMIC PRESENTATION.

BY- ALLEN, WILLIAM H. COONEY, STUART M.

UNIVERSITY OF SOUTHERN CALIFORNIA, LOS ANGELES

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AN EXPLORATORY STUDY WAS CONDUCTED TO EXAMINE THE NONLINEAR RELATIONSHIP BETWEEN HUMANS AND THEIR INFORMATIONAL ENVIRONMENT. THE FIRST PROBLEM WAS TO MEASURE THE RELATIVE EFFECTS UPON LEARNING OF (1) VISUAL IMAGES PRESENTED NONLINEARLY (CUMULATIVELY OR SIMULTANEOUSLY) AND (2) VISUAL IMAGES PRESENTED LINEARLY (SEQUENTIALLY). EXAMINATION OF THIS VARIABLE WAS ALSO EXTENDED TO INCLUDE VARIATIONS IN THE TREATMENT OF CONTENT - TO MEASURE THE EFFECTS UPON LEARNING OF SUBJECT MATTER PRESENTED AT SEVERAL LEVELS OF ABSTRACTION. EXPLORATIONS WERE CONDUCTED AT TWO GRADE LEVELS, SIXTH AND EIGHTH. EFFECTS WERE MEASURED ON THREE LEVELS OF LEARNING - KNOWLEDGE, COMPREHENSION, AND APPLICATION. EACH OF SIX FILMS SHOWN TO THE EXPERIMENTAL GROUPS WERE FILMOGRAPHS. RESULTS ARE REPORTED FOR EACH GRADE GROUP. FOR BOTH GRADE LEVELS IT WAS CONCLUDED THAT (1) MODE OF PRESENTATION HAS LESS EFFECT ON LEARNING AS THE STUDENT GROWS OLDER AND (2) ABILITY TO COMPREHEND AND TO APPLY SUBJECT MATTER OF THIS TYPE TAUGHT IN THESE WAYS IMPROVES WITH AGE. EXPLORATORY IMPLICATIONS OF THE DATA AND CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER STUDY ARE PRESENTED. (JC)

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**UNIVERSITY OF SOUTHERN CALIFORNIA**
**Research Division, Department of Cinema**
**Los Angeles, California**

**May 1963**

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Office of Education
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# I. INTRODUCTION

This study was designed and conducted to explore the principles of better matching between messages and men, between data and learner, between film and student. It postulated non-linearity as a concept of human variability and cosequently as a principle in the design of messages. It postulated non-linearity also as a characteristic of the communication event as it is structured in space and time and thus sought to explore the combined effects of two basic dimensions of message design upon learning: format, as each message is arranged in space; and content, as each message is arranged through time.

## A. THE PROBLEM

Non-linearity, the central independent variable in this experiment, was interpreted primarily in terms of the visual format of the stimulus messages (filmographs); that is, an attempt was made to manipulate the visual component of the messages and to control the oral component. Thus the first major problem of the study was to explore the relative effects upon learning (1) of visual images presented non-linearly, that is, cumulatively and simultaneously, one image next to the others; and (2) of visual images presented linearly, that is, separately and sequentially, one image after the others.

Examination of this central variable was also extended to include fundamental variations in content, thus providing insight into characteristics of the variable as it might affect learning on several levels of abstraction. Thus the second problem of the study was to measure the relative effects upon learning of similar content delivered with primary emphasis (1) upon description of factual content, (2) upon explanation of conceptual content, and (3) upon a nominal mixture of these two extremes.

Measurement of the effects of these variables upon learning was made on three levels of achievement: knowledge, comprehension, and application. These measures were taken immediately following exposure of subjects to the stimulus films and were taken again four weeks later.

The study was further partitioned to examine the operation of these variables at two grade levels (sixth and eighth) and with both sexes to provide insight into gross variations that might be a function of age and to examine differential effects of the variables as a function of sex.

Finally, in order to explore these experimental variables as they may have been related to implicit variability among the subjects and explicit variability in the environment, records were kept of the data that were descriptive of the subjects (IQ, Arithmetic Reasoning, Vocabulary, etc.) and descriptive of the environment (temperature, light, noise, etc.).

## B. TERMS AND SYMBOLS

Only terms used throughout the study are defined here. Terms having a more limited use are defined when they are first introduced.

Non-linear. A form of filmic presentation in which images are presented cumulatively and simultaneously on the screen. For purposes of the study, definition of this term was limited to operational characteristics of the film; however, the concept of nonlinearity was intended to encompass characteristics of the viewers as well as the film, and in the largest sense to refer to fundamental variability in human communication events. In this form of filmic presentation each succeeding image appearing on the screen remains visible while other images appear next to it. This accumulation is varied in rate of change and number of images throughout the length of the film.

Linear. A form of filmic presentation in which images are presented separately on the screen, each image disappearing as the succeeding image appears.

Factual. Filmic content having primary stress upon description in its sound track and using iconic (pictorial) representation in its visual imagery.

Conceptual. Filmic content having primary stress upon explanation in its sound track and using non-iconic (symbolic) representation in its visual imagery.

Combinations of these terms as they were used to represent the variables, films, and film groups easily became repetitious in the text of the report and lengthy when used to identify segments of tables or figures. To obviate these difficulties, the terms were coded. As these codes were introduced in the report, they were identified; however, since their use was so frequent, it was thought to be of value to include all of these appropriately identified in one place for ready reference when needed.

Variables (and sets of films)

| | |
|---|---|
| NL | Non-linear |
| L | Linear |
| F | Factual |
| FC | Factual-conceptual |
| C | Conceptual |

Sets of Variables

| | |
|---|---|
| NL:L | Format variables |
| F:FC:C | Content variables |

Film Versions and Film Groups

| | |
|---|---|
| NL/F | Non-linear/factual |
| NL/FC | Non-linear/factual-conceptual |
| NL/C | Non-linear/conceptual |
| L/F | Linear/factual |
| L/FC | Linear/factual-conceptual |
| L/C | Linear/conceptual |

## C. IMPORTANCE OF THE STUDY

This study has importance only as it yields insights that advance the cause of more effective communication. The following purposes and expectations were believed appropriate in this regard and are offered more to clarify conscious intent than to establish the boundaries of relevance.

The study sustained a trend, emergent from within instructional media research since World War II, toward identification of those elements in the use of media which, when properly applied, would yield increased effectiveness in the use of the media. Primary emphasis in this study was placed upon aspects of the postulated non-linearity variable. By so doing, a variety of other related media and audience characteristics could also be explored, particularly as they related to the concept of non-linearity. The study afforded opportunity to compare characteristics of convential and divided screens, to compare the symbolic and photographic treatment of the same content, to manipulate a primitive rhetoric of simultaneous (multi-image) presentation, and to observe audience reaction to messages designed according to these characteristics.

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## II. REVIEW OF LITERATURE

The following discussion is divided into three sections: the first delimits the scope of the survey and describes the approach that was taken; section two develops the background, concepts, and trends that formed a context for the study; and finally, the third section reviews relevant experimentation.

### A. DELIMITATION

In this study there was no marked lineage of conceptual development in the traditional sense, no series of crucial experiments tracing the development of controversy toward a revolution. The approach taken in the literature search, as in the experiment, was characterized by von Bekesy (1960) when he wrote,

> It is possible to distinguish two forms of approach to a problem. One, which may be called the theoretical approach, is to formulate the problem in relation to what is already known, to make additions or extensions on the basis of accepted principles, and then to proceed to test these hypotheses experimentally. Another, which may be called the mosaic approach, takes each problem for itself with reference to the field in which it lies, and seeks to discover relations and principles that hold within the circumscribed area.

Since the "circumscribed area" for this study was potentially very large, an attempt was made to converge quickly within the contextual literature upon those few experiments that were directly related; that is, to make the "elements of inquiry coagulate into an intelligible pattern," the mosaic (Hanson, 1958).

Procedurally, this convergent search was cyclical in character and was conducted continuously throughout the experiment. A conceptual structure for the study was postulated, which was closely related to the variables of the study, and relevant materials were gathered and reviewed. The bibliographies of these references were searched for more materials and more bibliographies until an "intelligible pattern" began to emerge. Experience with the variables and with these data provided criteria for being severely selective and for patterning the mosaic.

Background materials were selected that placed the study of messages appropriately within studies of the larger communication event system. Next, since this was a study of complex stimuli as they affect and are effected by the human elements in that system, brief mention of salient literature characterizing the variable relationships between humans and their informational environments seemed appropriate. Still converging, selective attention was given to materials that characterized the design of messages in that environment. Here selection was again restricted to those materials that were related to the variables of the study. Finally, and central in the convergent pattern, reports of experimentation related to one or the other set of variables were selected and are reviewed in Section C below.

## B. BACKGROUND

This was a study in message design: the match between men and message. Although the study was concerned primarily with the message, there was strong inclination to embed the study in the larger context of the message and thus to exploit the theoretical implications of the central concept, non-linearity. It became clear in dealing with this inclination that any thrust toward theory at this time would be premature, that indeed the study rests somewhere in the realm of pre-theoretical experimentation and formulation. However, as incomplete, disconnected, and multi-levelled as the elements of the mosaic of references were found to be, there was among them an obvious and potentially fruitful trend toward theoretical synthesis.

### Communication, an Event System

Fundamental to this trend were the verbal-pictorial models developed during the past fifteen years that characterized communication as a system of related elements. Some fifteen of these models were reported by Smith (1962). Among these, particular emphasis was placed by Fearing (1953) upon "the dynamics of the interrelated parts of the communication situation," thus specifying clearly the temporal dimension of his model. He characterized the message as a "structural stimulus field" within this event system. Carroll (1955), in his model, also characterized the message as a "physical event," and noted in addition that the decoding process may "not correspond perfectly with the message as transmitted." Newman (1962) in a paper on the utilization of data in the decision-making process, saw the study of this relationship between man and message to be a single problem: "It is impossible conceptually and experimentally to separate the data presentation (display) problem from the data selection and utilization problem." Carpenter (1953) in his releasor-organizer hypothesis, emphasized that in order "to insure desired degrees of commonality of understanding and uniformity of responses it is required that the ranges of individual differences of audiences be taken into account...." Communication may thus be seen as a time-ordered event system whose message elements may not be readily isolated from their designers or their interpreters.

## Human Variability

The essence of the non-linear characteristics of the designer-interpreters of messages is variability. Establishing the detailed dimensions of such characteristics is clearly beyond the scope of a study concerned primarily with message variables. However, given the integrative point of view expressed above, it seemed necessary--if only to the symmetry of that concept--to introduce salient features of relevant literature.

One of the earliest and most provocative statements concerning varying states of human awareness was made by William James. While discussing variations in the "changes of our mental content," James (1890) wrote that the

> difference in the rate of change lies at the basis of a difference of subjective states of which we ought immediately to speak. When the rate is slow, we are aware of the object of our thought in a comparatively restful and stable way. When rapid, we are aware of a passage, a relation, a transition from it, or between it and something else. As we take, in fact, a general view of the wonderful stream of our consciousness, what strikes us first is this different pace of its parts. Like a bird's life, it seems to be made of an alternation of flights and perchings.... The resting-places are usually occupied by sensorial imaginations of some sort, whose peculiarity is that they can be held before the mind for an indefinite time, and contemplated without changing; the places of flight are filled with thoughts of relations, static or dynamic, that for the most part obtain between the matters contemplated in the periods of comparative rest.
>
> Let us call the resting-places the "substantive parts," and the places of flight the "transitive parts," of the stream of thought. It then appears that the main end of our thinking is at all times the attainment of some other substantive part than the one from which we have just been dislodged. And we may say that the main use of the transitive parts is to lead us from one substantive conclusion to another.[1]

---

[1] These remarks of James's reflect, in turn, not only his own insights but also the current ideas of his period, for example: the concepts of the then emergent psycho-physics of Weber (Andrew Seth

More recent and possibly more technical expressions of this variability have been made by engineering psychologists. These people have been particularly concerned with designing messages and machines for use by humans. In this regard Biser (1952) wrote:

> The human communication network is too complex to be regarded as a mere linear servomechanism.... Unlike electromechanical elements, the sensory inputs introduce many anomalous and unorthodox response features, such as response delay consisting of perceptual time, discrimination time, and reaction time.... The human operator, in the role of a control system, is highly variable, nonlinear, discontinuous and intermittent.

In brief, "the human, from an engineering point of view is not a 'nice' system. It is nonlinear, it changes with time, it exhibits great variations between individuals" (Belanger, 1962).

When individuals gather into audiences, their collective variability may be assessed by conducting profile analysis (Twyford, 1954). Profiles of the responses to the same message by several audiences were said by Twyford to show "surprising concurrence." Similar concurrence, with even greater precision, is also evident in the very detailed codifications of human variability compiled for use in human engineering (Woodson, 1954; Augenstine, 1958). Thus even though the dimensions of response were principally subjective for Twyford's audiences (like-dislike, prediction of learning, clarity, goodness, etc.), and objective for the engineers (measures of anatomy, senses, performance, etc.) their results provide evidence for patterns of variability that have sufficient stability to be useful in both the design and the evaluation of messages.

Message Design

Predictive variability in the relationships between men and messages is in part a function of the way in which each man perceives the delivered message, but it is also a function of the structural features of the message itself. In this study two of these

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Pringle-Pattison, "Weber's Law," Encyclopedia Britannica [Chicago: Encyclopedia, Inc., 1947], pp. 469-470; the original "Der Tastsinn und das Gemeingefuhl" was first published in 1846), and the consequent philosophical observations upon concrete duration and abstract time by Bergson (Henri Bergson, Time and Free Will [New York: Harper and Brothers, 1960]; the original Essai sur les données immediates de la conscience was published in 1889).

features, considered to be fundamental, were selected for initial examination: format of the image presentation, and treatment of the substantive content.

Format. Manipulation of the edges and relationships of filmed images has been fundamental to imaginative use of the film medium from its earliest applications in entertainment to its recent roles in education, propaganda, and industry. In his 1915 film "Birth of a Nation," Griffith used an "iris" to introduce the key element of a scene as a small spot somewhere on the screen. He then gradually enlarged the spot to introduce additional elements, thus constructing a larger conception of which the initial element was central. A year later, his film "Intolerance" expanded the technique to include a variety of masks for directing audience attention to particular areas of the screen (Jacobs, 1959). By the mid-twenties, in the film "Napoleon," Abel Gance had separated the screen into three permanent divisions. For emphasis, at points throughout the films, he projected parallel sequences on each of the screens simultaneously (Rotha, 1949; Kracauer, 1947). Eastman Kodak, in the Worlds Fair of 1939, introduced a large scale, three-screen display "Vitarama," thus further extending the concept of multi-image presentation (Business Screen Magazine, 1949; Monaghan, 1939). Apparently the idea was lost until in 1947 Life magazine capitalized on its pictorial prowess to develop "Picturama," a multi-imaged presentation of the American way of life. This travelling exhibit inspired the Seagram Distillers Corporation to develop possibly the first of what has become a standard in marketing, the travelling sales meeting that utilizes audio-visual devices for intensive delivery of concepts in merchandising. Seagram's "Vitarama" used live "drama" and five 15 x 40 screens to illustrate distilling methods to salesmen (Business Screen Magazine, 1948).

In the fall of 1952, George Nelson, Charles Eames, and Alexander Girard conducted an "experiment" for the University of Georgia to demonstrate how the "industrial approach" could be used to teach art. They used motion pictures, tape recorders, three slide projectors, three screens, and a "collection of synthetic smells" to communicate "something specific----without loss of comprehension or retention"[italics theirs] (Nelson, 1954).

In mid-decade, Disney Studios introduced a "Circarama" display for the American Motors exhibit in Disneyland Park, Anaheim, California. Using eleven screens arranged in a circle 40 feet in diameter and eight feet off the floor, the exhibit presented pictorial and audible evidence of the pleasures of motor travel to a standing audience. The 16mm filmed images were shot and projected synchronously (Allen, 1955).

About this same time, Glenn Alvey introduced his much-refined version of Griffith's "iris" in the film "The Door in the Wall." Called the "Dynamic Frame," the system "allows the cameraman to choose any rectilinear composition and to vary it in time by graded steps during the scene to any other preselected size and proportion within the limits of the negative frame (Hill, 1957; Prouse, 1955-56). This approach permitted positive control of the viewer's access to specific or related elements on the screen, a control also exercised in multi-imaging when a single image or screen is used momentarily, and then other diverse or closely related images are added.

By 1958, widespread interest in the use of film, in particular the multi-screen multi-image process, was evident in the Brussels Exposition. Mosby reported that "Nearly every pavilion...has a movie theatre for exhibition of 'travelogues' relating to the beauties and accomplishments of its country" (Mosby, 1958). Many of these were of the many-imaged variety. For example, the Italians used three big screens in their "Aviorama," ...one at the feet of the audience, one on the ceiling, one at eye level...." The Belgian Congo exhibit used wing screens for "showing other films." The Checkoslovakian approach, "invented" by Emil Radok and called "Polycran," used

> eight screens of slightly different shapes...placed in a small recessed stage lined with black. Two of the screens hang virtually from the ceiling, but tilted for good viewing. Two are tilted upward from the floor and the other four are scattered at eye level. The audience sits on stools to watch the ten-minute performance.

Alfred Radok, brother of Polycran's originator, Emil Radok, used the multi-screen technique to solve a language problem in presentation. The dancer, narrator, Miss Danickova,

> became triplets. She appears at the same time, via film, on two long narrow screens that flank the Cinemascope screen. In one she speaks French, in another Flemish. Then the real-life Miss Danickova steps out on the stage in person to speak English and chat with her two filmed selves.

This system, called "Magic Lantern" also used the masking techniques introduced by Griffith. Mosby reported that during the sequence described above, "the bottom two thirds of the screen is blacked out. In the top third, only the feet of some folk dancers are visible." The Magic Lantern exhibition was designed to travel, and was later shown in Moscow and in London (Robinson, 1961).

Eames, describing his 1959 multi-screen exhibit in Moscow, related his innovations to the picture-magazine's speed of delivery and to its credibility.[2]

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[2] Personal communication.

He chose seven screens and "some 2200 transparancies...to create an air of credibility" for what was displayed by the U.S. at the Exhibition (*Business Screen Magazine*, 1962). Also to be seen in Moscow at this time was Russia's "Kinopanarama," enlarged version of Disney's Circarama described above. The Russians used 22 screens arranged in two circular layers of 11 each; the lower screens were 12 feet high and 8-1/2 feet above the floor, and the upper screens, tipped at a 59° angle, rose some 13 feet above the lower screens. The whole array was over 90 feet in diameter and displayed a 20 minute sequence to a standing audience of 300 people (Voyce, 1960).

People in business and industry, meanwhile, were apparently impressed by the communicative potential of these exhibitions. Ford Company used a tent-housed travelling display as a "better way of taking our cars to the people." Their "Quadravision," designed to be set up in shopping-center parking lots, used four flanked screens in combination with live presentations and simultaneous action on all screens (*Business Screen Magazine*, 1959). Weiss used five smaller screens plus one large, centered screen "to show compensation insurance carriers that rehabilitation programs are a good investment" (Hughes, 1960). Overturf (1962) used two back-projection screens, models, viewing windows, and photo-displays in combination to interpret the role of computers in military systems to people visiting a computer installation. Perhaps ultimate evidence for the ubiquity of interest by business and industry in these modes of presentation may be found in the special issue of the *Sales Management* (1962) devoted to communication in sales meeting. Seven articles in that issue include discussions of multi-image presentations.

In training and education, developments have been no less impressive. Since 1950, Teleprompter Corporation has been developing its five-screen "Telemation" technique for large-group instruction. As of July 16, 1962 this company listed some 90 military and government installations, including four "Presidential Briefing Rooms." Their system is also being used at the university level for instructional purposes.[3] Eames used six screens to introduce science to visitors at the Seattle World's Fair (*Business Screen Magazine*, 1959). And, finally, perhaps the most novel extension of this approach to visual communication was developed by Kenneth Isaacs of the Illinois Institute of Technology. His "Matrix," a twelve-foot, completely enclosed cube, uses 24 slide projectors to project four images on each of the six interior surfaces (Welch, 1962). When shown to subject-matter specialists, it was agreed

> that the multiple inputs offer a more accurate and complete picture...than do a lecture, a book, or an ordinary movie;

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[3] Personal communication with their management.

> the latter are limited in information-carrying capacity to a linear construction and must rely on the flashback to relate one bit to another, whereas the Matrix can perform in simultaneous phase, producing a communication of greater fidelity (Isaacs, 1962).

Clearly, in communication practice there has been considerable interest in the kind of variation in film format that has been addressed by this study. One might see this interest to be rooted in the never-ending search for novelty, and to some degree this has probably been true. However, the rate and emphasis in these developments suggest that one primary motive has had to do with a search for greater efficiency in the delivery of messages and the discovery that humans can accommodate great quantities of information at relatively high rates of speed. As Nelson (1954) saw it, in measuring success in their project, "the yardstick was a clock." Eames believed that "the number of levels of information that can be communicated is fantastic."[4] McLuhan (1960) wrote, "The Problem for artists in our time is to say everything at once...." Isaacs (1962) in referring above to the "information-carrying capacity" of his Matrix, saw simultaneity of presentation as a major advantage in this mode of presentation. When viewing many images presented simultaneously, a Russian film critic pointed out, "the viewer becomes the author of the montage and directs his attention to those segments which interest him the most...." (Arkadyev, 1960). The parallelism of action," wrote Svoboda (1960) in a later issue of the same periodical, "brings about new emotions which stem from the interrelationship of those images...." Thus the viewer of multi-image presentations addresses not only many images, but also the relationships among them, and although his preference for this kind of complex experience seems evident, his tolerance for it appears to be limited.

Complexity, Berlyne (1958) has pointed out, is preferred by humans who "have a tendency to fixate a part of the environment that is a relatively rich source of information in preference to one that is a relatively poor one." This was confirmed by at least one observer of Eames' Moscow films who said that "he couldn't look away."[5] Eames said he intentionally provided "more than the viewer could stand.[6] However, his films were designed primarily to influence attitudes and to "create an air of credibility" (*Business Screen Magazine*, 1962). In the learning situation, on the other hand, there seems to be an adverse effect if complexity is increased beyond a "necessary minimum"(Attneave, 1959). As Reed (1946) put it,

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[4] Personal communication.

[5] Richard Tuber, personal communication.

[6] Charles Eames, personal communication.

"The amount of effort to learn increases in almost a straight-line manner as complexity increases...there is a definite trend to shift from logical to illogical learning." This conflict between preference and performance is in some degree fictitious, for the types of messages referred to above and their event systems are quite different. However, the strategies used by the human in resolving this apparent conflict seem to be fundamental to each of these points of view.

Arnheim (1954) has suggested that "neither the eye nor the mind is capable of taking in everything simultaneously," but rather that the "observer scans various areas of the picture in succession." Buswell (1935) and Enoch (1959) have demonstrated this point experimentally. Gombrich (1961), too, has said that "reading a picture is a piecemeal affair that starts with random shots and gradually adjusts to the coherence of the work." Arnheim (1954), who unlike Gombrich, sees the message as central in this event system, has postulated the thematic structure of the image itself to be the organizing principle, one that is "comprehensible only when all the relationships it involves are grasped as being coexistent." The resolution, then, seems to be implicit in the design of the message, a design that will satisfy the preferences of the observer, but that will not exceed his capacity for complexity. Even this capacity, Newman (1962) has suggested, may be increased: "An individual in a particular environment will be most responsive to those stimuli that are *more complex* by some increment than his preferred level." He proposes the use of "pacer stimuli" that will force the subject's preferences to higher levels of complexity.

*Content*. Manipulation of the format of the stimulus films was also conducted along a dimension of increasing abstraction in the treatment of content. Both the visual and the verbal elements of the films were modified by "orders of abstraction" (Korzybski, 1948) ranging from precise reference to the observable "things" of reality (Lewis, 1956) to their symbolic and conceptual interpretations (Langer,1942). It was recognized that the selective characteristics of the filmed image (Lindgren, 1948), the language on the sound track (Bloomfield, 1939; Whorf, 1956), and the humans producing and observing the composite film (Bruner and Postman)[7] made high-order abstractions of the stimulus films themselves. Thus the concern of this review has been with relative degrees of verisimilitude rather than with a range from sense data to complex symbol systems, as would surely be the case if the perceptual aspects of this dimension of message design were being considered in depth.

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[7] Reference is made here to their postulated "adaptive factor" called "selective vigilance...which tunes perception to the service of the needs and attitudes of the adapting organism...."

Interest in this dimension of human experience has been reflected in the variety of labels that have been attached to it. Perhaps the most familiar has been concrete to abstract (Chaplin and Krawiec, 1960; Johnson, 1961; Korzybski, 1948), but there have been several others, particularly for the visual element: veridical to schematic (Smith, 1957), representational to non-representional (Arnheim, 1954), iconic to non-iconic (Morris, 1946; Hartshorne and Weiss, 1931), high-definition (HD) to low-definition (LD) (McLuhan, 1960), and factual to conceptual (Allen, 1960; Hoban and van Ormer, 1950)[8]. The last of these was chosen as the label used in this study principally because it aptly represented not only the visual-verbal components, but also because it carried with it the structural and substantive emphasis that was desired.

Along this same dimension of abstraction, verbal emphasis was distributed in much the same way as visual emphasis, from the factual to the conceptual, the denotative to the connotative (Langer, 1942), the descriptive to the interpretive and explanatory (Korner, 1959). As the factual end of the spectrum, although there could not be as direct a correspondence between the word and object as between photograph and object, the emphasis was referential, "concerned with setting forth the facts of the situation," describing the what of a process (Westmough, 1957). At the other end of the spectrum, the conceptual emphasis moved away from sense appearances in the direction of uniformities, predictable patterns, the how of a process (1956). "Conceptual" in this context was used in the sense defined by Cohen (1956):

> Concepts are signs (mainly audible or visible words and symbols) pointing to invariant relations, i.e., relations which remain identical despite the variations of the material in which they are embodied. Significant concepts, therefore, enable us to arrange in order and hold together diverse phenomena, because of some real unity of process or relations which constitutes an element of identity between them.

Thus, in the sound track of the conceptual films an attempt was made to interpret and explain the physical processes that were only described in the factual versions and to provide a "conceptual pattern" for relating these processes to the generalized experience of the observers (Hanson, 1958; Wertheimer, 1959; Bruner, 1960).

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[8] "Factual" and "conceptual" were used by these authors to refer to types of knowledge.

## C. EXPERIMENTATION

Since no reports of studies directly relevant to this combination of variables were found, it becomes necessary to invoke again the "mosaic" approach that was prescribed by von Bekezy and presented earlier in this review. The materials reported below have been drawn from diverse sources and have been fitted together into a pattern suggested by their content and relevance rather than by their continuity of development. It seemed appropriate, therefore, that these materials be partitioned according to their relationships to the factual and the conceptual variables.

### Factual

As reported above, The Teleprompter Corporation has for a number of years been advocating and applying its five-screened "Telemation" system to information-conveying situations. Early in January of 1958, the Army Ordnance Guided Missile School initiated a series of evaluation studies to appraise the effectiveness of this approach in their training program. Ninety-six out of a total of 1056 hours of instruction were conducted in this fashion using one experimental and one control group in each of three 32-hour segments. Each segment emphasized different types of subject matter. The experimental delivery combined visual effects with scripted oral delivery. For approximately the same achievement scores, savings in instruction time varied from 19.5% to 41%. Surprise retention tests given nine weeks later showed a 4.7 point increment (total scores not reported) for the experimental groups. These preliminary results were reported when the study was 60% completed. Final results were not available for publication. Emphasis in the report was placed upon the care taken to prepare the materials for the experimental phase of the study (United States Army, 1959).[9] This suggested that possibly the time saved in instruction--the main value reported for the technique--was as much a function of this care in preparation as it was a function of the multi-imaged delivery of the subject matter.

Perception of still images by children was of central concern in a series of studies carried out by Claude Malandin of the Centre de Recherches et d'Etudes pour la Diffusion du Français, St. Cloud, France. An early study used a multi-imaged, four-by-four matrix

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[9] Reference is also made to personal correspondence with Captain J. W. Nicks of the Arsenal. Captain Nicks said that these studies had been superseded: "The audio visual techniques now being employed by the school do not include any outstanding developments in the area of multiple imaging. Our requirements in this area have been adequately satisfied by employing television special effects, including split screen, and multiple or divided screens for other visual equipment"; received 8 October 1962.

(16 images) displayed as prints on paper and as a single transparency on a screen, the principal differences being size and distance. The horizontal rows showed four persons in turn at different moments of the day, while each vertical column showed the same person alone or in a group composed of those shown in the rows. The problem was to detect what variations, if any, might exist in the perceptions of these two media by pupils in the first four primary classes. Each child was asked to tell, in personal interview, what he saw in the pictures. Children who had seen the images on paper "spontaneously viewed the images in the same order as they would read a text. But when the images were screened, the children did not feel compelled to view them in the same order, and, in fact, nearly a quarter of them failed to establish any orderly sequence.... Comments on images on paper [were] no longer out of order after the 2nd year, while this defect continue/d/ until the 4th year in the case of the screened images" (Malandin, 1962).

Given the insight into variations in perception as a function of age and of medium, Malandin undertook another study. This time he investigated children's ability to interpret a series of graphic images. Each of two hundred children in four primary classes saw three short, silent filmstrips, after which each child was asked to explain what he had seen. Then he had an opportunity to see and comment upon each frame separately. It was found that the younger children could not relate the successive images logically one to the other. Therefore, in conclusion Malandin (a, no date) wrote:

> It would seem desirable to divide a story into two or three essential stages. The images relating to each one of these stages would be regrouped onto a single slide and projected simultaneously before being analyzed successively. The child could thus read the images at his own rhythm, take more time on the more difficult images, and go back. The disposition of the images side by side would help the child to establish logical links among the images.

To test this idea, Malandin (b, no date) took one of the three filmstrips mentioned above and divided it into three groups of images: one group of four images, one of five, and one of two. Each of the thirty children, aged nine to eleven years, was shown the grouped frames twice. Each was then asked to relate what he had seen. Each then saw and commented upon individual frames. The results were compared to data collected in the series study reported above. Malandin found that "grouping the frames permits an increase in the number of recollections, but, above all, better organization of recollections." This difference decreased with age. Roshka (1960) also found that "simultaneous presentation proves to be more effective than subsequent addition, especially with smaller children."

## Conceptual

That films can teach both facts and concepts has been adequately demonstrated by studies reviewed by Allen (1960) and by Hoban and van Ormer(1950). No studies were reported, by these or other authors, that examined effectiveness of films depicting the same content treated in varying degrees of abstraction. However, several studies were found that were suggestive of what might affect the results of this experiment even though they were conducted under somewhat different conditions and for different purposes.

Long and Welch (1942) used both photographs and words, differeing in level of abstraction, to study effects upon the abilities of children to generalize known principles. They concluded that "increasing the abstractness, either by varying the medium of presentation or by varying the hierarchy level, will affect adversely the child's ability to apply a principle of reasoning." They also found that this difficulty decreased with age.

In a study by Ismael, Puerto Rican children of the 2nd, 3rd, and 6th grades were shown three pictures, depicting exactly the same scene. The children consistently chose the most realistic first, the next most realistic second, and the least realistic last." These two studies, and others with somewhat less relevance to the content variables being examined in this study, suggest that preferences for pictures and level of difficulty are related to the evolution of perceptual awareness characterized in the Maladin studies reported above (Spaulding, 1955; Allen, 1960; Johnson, 1955). Preference and difficulty may simply be a function of readiness to perceive.

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## III. PLAN OF THE EXPERIMENT

The experiment was designed to gather data on the relative effects of six films on learning, each film containing essentially the same information but varied in format and treatment of content, and each presented to randomized audiences of sixth and of eighth grade students, respectively. Each film's effects were measured by testing for student learning of knowledge, of comprehension, and of application as defined by Bloom (1956). The student groups at each class level were assigned randomly to view one of the six films. The viewing and testing situations were controlled for environmental variables such as light levels, noise levels, and temperature levels; for facilities such as projectors, screens, and loudspeakers; and for extra-experimental information such as introductions, and instructions. A test was given immediately following the film and also during the fourth week after the experiment. The data were analyzed using a variety of statistical techniques.

### A. EXPERIMENTAL DESIGN

This study utilized a 2x3x2 factorial design wherein variables were "studied in all possible combinations in the same experiment" (Edwards, 1950). The distribution of the experimental variables studied is shown in Figure 1.

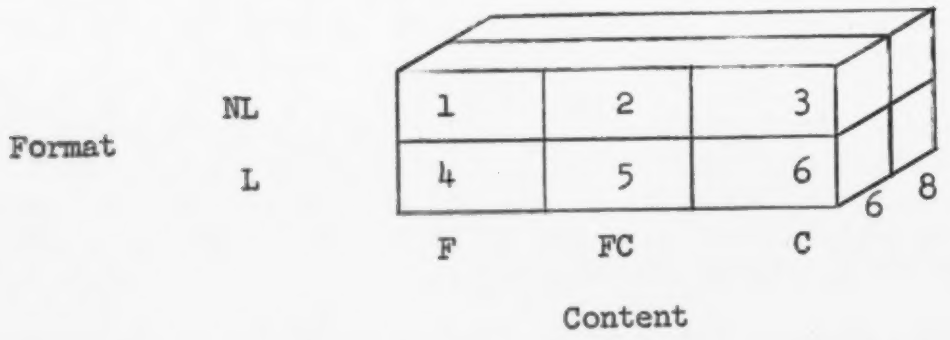

FIGURE 1

EXPERIMENTAL DESIGN

#### Experimental Variables

Format Variables (NL:L). Non-linear (NL) and linear (L) variations in format were differences principally in the manner of presenting discrete visual images. The three films in the non-linear format (films 1, 2, and 3 in Figure 1) presented multiple images cumulatively on a single screen. Respondents could thus re-scan, relate, and re-associate visual patterns with the developing informational structure of the film. Thus, visual content was "bunched"; that is, images accumulated to fill the screen, or were similarly replaced, until a given sequence was completed, then each sequence was separated from each succeeding sequence by brief rest periods of empty colored screen. Early sequences in each film presented images at a slower rate of accumulation and in smaller numbers than sequences later in the film. In this way opportunity was given for each student to learn to manage what would be for him a strange technique of presentation.

Film versions in the linear format (films 4, 5, and 6) presented images in discrete sequence, isolated, one after another, so that the accumulation took place only in the memories of each respondent. It was postulated that the linear format was an experimental analogue of the presentation format used in most educational and informational films.

Content Variables (F:FC:C). Each of the three pairs of films also emphasized elements of informational content in different ways. The sound track for each content pair (non-linear and linear) was identical. The factual pair (F), films 1 and 4 in Figure 1, emphasized description and process, the "what" and "how" of the content. Conceptual content for this pair of films was held to a bare minimum both in the sound track and in the images. Representational pictorial art and photographs, called "iconic" by Charles Morris (1946), were used exclusively. The conceptual pair (C), films 3 and 6 in Figure 1, emphasized explanation and structure, the "why" of the content. Non-representational drawings and symbols, called "non-iconic" by Morris, were used to characterize, to emphasize, and to make explicit the conceptual content of this pair of films.

The factual-conceptual pair of films (FC), films 2 and 5 in Figure 1, mixed the emphases in the contents of the two extremes. Where appropriate, the sound track shifted emphasis from description to explanation, and in each case the shift was supported by a comparable shift in the iconicity of the images.

The size, number, position and length of exposure of images in these linear versions were strictly controlled by the comparable size and position of the same images in the related non-linear versions. It was recognized early that this control tended to compromise the aesthetic decision-rules normally used in routine film productions; but without this control the films would not be comparable experimentally. Whenever production decisions of this sort were made, the accepted compromise always favored requirements for experimental controls.

Grade. Each of these two dimensions of message design, and their associated variables, were studied at two grade levels, six and eight, using the same set of stimulus films, the same measuring instruments, and the same controls. Thus, even though the resulting data were analyzed differentially, treating the two grades as separate replications of the same experiment, it was believed that this symmetry of treatment would permit judicious comparisons of the results, thus yielding some insight into the effects of maturation upon the variables.

Dependent Variable. The dependent variable in the study was learning. In order to enhance the generality of the study, the measures of learning that were used were based upon Bloom's categories of Knowledge, Comprehension, and Application. Knowledge, as defined by Bloom (1956, p. 62),

> includes those behaviors and test situations which emphasize the remembering, either by recognition or recall, of ideas, material, or phenomena.... In the classification of knowledge objectives, the arrangement is from the specific and relatively concrete types of behaviors to the more complex and abstract ones. Thus, the knowledge of specifics refers to types of information or knowledge which can be isolated and remembered separately, while the knowledge of universals and abstractions emphasizes the interrelations and patterns in which information can be organized and structured.... The Knowledge category differs from the others in that remembering is the major psychological process involved, while in the other categories the remembering is only one part of a much more complex process of relating, judging, and reorganizing.

It was thus assumed that each student had to have knowledge in order to comprehend, and had to comprehend in order to apply.

Comprehension, the second category of learning used by Bloom refers in this study to the understanding by student subjects of the literal message of the stimulus films. Three types of behavior that represented comprehension were included (1956, pp. 89-91):

> 1) translation, which means that an individual can put this communication into other language or terms or forms of communication...;
> 2) interpretation, which requires a reordering of the [film's] ideas into a new configuration such as the making of inferences, generalizations, or summarizations..., [and]
> 3) extrapolation, which includes the making of estimates or predictions based on the understanding of the conditions described in the [films], and includes as well the extension

> of this understanding into problems not included explicitly in the [films]--implications, consequences, corollaries,... [etc.].

Application, the third category of learning presented by Bloom refers to the use in novel situations of knowledge learned by students from the films. Thus application "includes a demonstration that a student will use his knowledge correctly when given an appropriate situation in which no mode of solution is specified" (1956, P. 120). This differs from comprehension, which shows that the student can use his knowledge when its use is specified. Application includes the transfer of training to a new area and thus requires restructuring of knowledge to make possible the development of an appropriate solution.

The measures thus devised were administered to each group immediately after exposure to the films in order to assess original learning, and were administered again four weeks later in order to assess forgetting (or remembering). According to Fearing, forgetting (or remembering) is "a dynamic process in which the individual retrospectively structures a situation in terms of his needs and values" (1962). It was expected that this process would be different for each film.

## B. EXPERIMENTAL CONTROLS

Controls applied in the study included the collection of data descriptive of the selected population, randomized distribution of the population among the twelve experimental and two control groups, collection of data descriptive of the environment, and establishment of strict comparability in the selection and use of materials, equipment, and facilities during presentation and testing.

### Criteria for Selecting the Experimental Population

In order to increase the generality of results, early consideration was given in the study to a procedure for selecting schools at random from within several geographic areas representing rural to urban locations, and high to low economic status (Conrad, 1951). The realities of administration, of intent, and of expectation suggested an alternative approach: selection of a single school district that was reasonably representative of a norm, and that contained within it the numbers of students and flexibility of schedules and facilities required for the study.

Representativeness. It was recognized that no suburb of a metropolitan area as large as Los Angeles could reasonably be considered typical. Yet it was believed that there could be elements within such a satellite community that could in themselves be representative. If, for example, the community had industrial, mercantile, and agrarian components in its economy, then it would undoubtedly have children from these cultural elements in its schools. If the schools were of reasonably recent origin, then it would likely be a young community, and the school system would likely contain within it the kinds of facilities required for the study. These more qualitative criteria for representativeness were applied in the selection of the schools to be used rather than the possibly more desirable statistical sampling techniques.

Facilities and Controls. Of critical importance to the study was the availability of consistently controllable viewing and testing facilities. Given the large size of the population desired at each grade level, it was clearly impractical to transport each group to a central point where the films might be shown and the tests given under controlled conditions. Thus a second criterion was that the system selected must have comparable facilities for viewing films and for testing its students.

Access. Optimal scheduling of limited facilities for instructional purposes was known to be a routine objective among the school systems under consideration. The required experimental procedures were thus to be an intrusion upon this scheduling since they were clearly extra-instructional. A third criterion thus required willingness on the part of the supervisory staff of the chosen system to provide access to their facilities and their students for the duration of the experiment.

Size. Twelve groups of students were to be used in the experiment, each group to contain some eighty students initially. In addition, two small control groups were required, each to contain some twenty-five students initially. Attrition and missing data were expected to reduce these numbers somewhat. Thus, the selected system was expected to yield some 500 students at each grade level. In addition, these students had to be so grouped as to permit random assignment to each film, thus yielding homogeneity among the groups.

## Characteristics of the Population

The Fullerton School District of Orange County, California, was selected as the experimental school system. It met all the criteria listed above; was convenient geographically; and, importantly, the supervisory staff members were keenly interested in the study and offered willing cooperation in meeting the requirements for access and control. Two elementary schools were used for tryout, and four elementary and one junior high were used as experimental schools.

Students were selected from within the system principally on the basis of their attendance. Since they were to be randomly assigned to the films, it was believed that no further selection procedures were necessary. A total of 1063 students participated in the experiment. Of this number 63 participated in the first test tryout, 55 in the second, and 44 were drawn from the eighth-grade sample to supply control data as described below. Thus a total of 901 students were assigned to view the films, receive the immediate test, and receive the delayed test--i.e., to participate in the experimental phase of the study. Of this 901, 440 were girls (48.8%), and 461 were boys (51.2%); 462 were in the sixth grade, and 439 were in the eighth grade. The mean age for the sixth grade was 11.78 years, and for the eighth grade 13.44 years.

Distribution of Population Among Films. The basic mechanism used for assigning students to films was the table of random numbers as described by Edwards (1950). The basic procedure followed was quite simple: first each film was given a group designation, each student was then numbered uniquely, and, finally, these numbers were assigned randomly to groups.

Because the projection facilities in the eighth-grade school permitted relatively large audiences of students to view films, the 439 eighth-grade students could be partitioned conveniently into six groups. Each of the six groups was assigned a code letter and each letter was assigned randomly to one of the six films. Next, each student listed as attending the eighth grade at this school was assigned a number in sequence. Each number was in turn assigned randomly to one of the code letters. The number, the code letter, the student's name, and his scheduled viewing time were then transferred to 3x5 cards of six colors to be used later as the mechanism for scheduling the transfer of each student from his class to an experimental group.

Because the 462 sixth-grade students were located at four different schools, and were to be randomly assigned to six films, each of the four grades was split into three groups of about forty students. This partitioning also accommodated the control requirement for limiting the size of any single group of viewers to the capacity of the smallest sixth-grade projection facility. Each group was then assigned randomly to the code letters so that no film was shown twice at the same school. In this way the total group of about eighty students seeing each film included within it students from two schools. The randomization process was thus extended across the four sixth-grade schools.

Absences on the day of the delayed test reduced the total from 901 during the immediate test to 836 for the delayed test.

Characteristics of the Film Groups. Data descriptive of the population were further analyzed to show the results of the random assignment, in particular to show any major deviations among the groups. The mean ages of the groups that took the immediate test are shown in Table I. Also, since the experimental data were to be

## TABLE I

## MEAN AGES OF IMMEDIATE TEST POPULATION BY FILM (N = 901)

| | F | F-C | C | TOTALS |
|---|---|---|---|---|
| N-L | 11.81 | 11.83 | 11.76 | 11.80 |
| L | 11.81 | 11.73 | 11.75 | 11.76 |
| | 11.81 | 11.78 | 11.76 | |

A. MEAN AGE FOR SIXTH GRADE: 11.78 YEARS

| | F | F-C | C | TOTALS |
|---|---|---|---|---|
| N-L | 13.42 | 13.52 | 13.39 | 13.44 |
| L | 13.48 | 13.37 | 13.50 | 13.45 |
| | 13.45 | 13.44 | 13.44 | |

B. MEAN AGE FOR EIGHTH GRADE: 13.44 YEARS analyzed by grade, using sex as a way of the analysis in order to provide control of sex as a variable, and using Language IQ and Arithmetic Reasoning scores as covariates, data were also gathered that were descriptive of the population. These data were drawn from the files of the school system and are presented below in a manner that preserves the anonymity of individual students. These statistics were based upon scores made by the students on the California Achievement Tests, form "X" for the sixth grade, and form "Y" for the eighth grade (Tiegs and Clark, 1957). Mean scores for Language IQ by grade, by film, and by sex are shown in Table II, and for Arithmetic Reasoning in Table III. Where data were missing, the mean score for the population was used in the calculations.

Control Groups. Testing was done immediately following the film showing for each group, and was done again four weeks following this exposure. Because it was believed that the results measured by the four-week test might reflect learning as a function of the film and the test as a single stimulus unit, a control procedure was included in the experimental design that would isolate the film as stimulus from the test as stimulus. This control was achieved by selecting 25 students at random from each of two experimental groups (assigned to the eighth-grade, factual-conceptual/linear and non-linear films). These students were then excluded from the immediate test but were given the delayed test along with the rest of the population. The scores of these two control groups could then be interpreted as a function of the film exposure exclusively (assuming no interaction between themselves and the experimental groups about the films) and, when compared with the scores of the comparable experimental groups, would provide an index of the relationship between films and test as they affected learning.

## Environment

Controls were exercised over the environment of the experiment by making changes where necessary and possible, and by keeping records of conditions where such manipulation was not possible. These records then provided a check on the existence of deviant environmental conditions that might occur during the experiment.

Space. Although some variability was found in the size of rooms used for projection purposes, classrooms used for testing were remarkably uniform. With the exception of the Orangethorpe school, all of the schools were built on essentially the same design. The available projection rooms were all large enough and flexible enough to permit the arrangement of equipment that was used in the experiment.

Light. Uniformity of design extended its effects into the lighting conditions for each of the schools. Light levels in the

## TABLE II

## DISTRIBUTION OF MEANS FOR LANGUAGE IQ
## BY GRADE, FILM, & SEX (N = 901)

| | | F | | F-C | | C | | MEANS ($\bar{X}_t$) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | M | F | M | F | M | F | M | F | $\bar{X}_{tt}$ |
| N-L | Sex | 109.5 | 111.1 | 112.3 | 109.1 | 106.8 | 112.0 | 110.2 | 110.8 | 110.6 |
| | $\bar{X}_t$ | 110.4 | | 110.9 | | 110.7 | | | | |
| L | Sex | 108.5 | 110.0 | 113.4 | 112.0 | 110.1 | 104.4 | 110.7 | 108.8 | 109.8 |
| | ($\bar{X}_t$) | 109.2 | | 112.7 | | 107.5 | | | | |
| MEANS | | 109.0 | 110.5 | 112.8 | 110.5 | 109.5 | 108.2 | 110.4 | 110.0 | 110.2 |
| | ($\bar{X}_{tt}$) | 109.8 | | 111.8 | | 109.2 | | | | |

A. SIXTH GRADE (N = 462)

| | | F | | F-C | | C | | MEANS ($\bar{X}_t$) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | M | F | M | F | M | F | M | F | $\bar{X}_{tt}$ |
| N-L | Sex | 104.8 | 103.4 | 102.0 | 105.2 | 108.8 | 105.3 | 105.2 | 104.3 | 104.8 |
| | $\bar{X}_t$ | 104.2 | | 103.9 | | 107.1 | | | | |
| L | Sex | 108.8 | 101.7 | 108.2 | 106.6 | 104.1 | 106.2 | 107.0 | 104.5 | 105.8 |
| | ($\bar{X}_t$) | 105.1 | | 107.2 | | 105.1 | | | | |
| MEANS | | 106.2 | 102.5 | 105.1 | 105.9 | 106.4 | 105.7 | 106.1 | 104.8 | 105.4 |
| | ($\bar{X}_{tt}$) | 104.6 | | 105.5 | | 106.1 | | | | |

B. EIGHTH GRADE (N = 439)

## TABLE III

## DISTRIBUTION OF MEANS FOR ARITHMETIC REASONING BY GRADE, FILM, & SEX (N = 901)

| | | F | | F-C | | C | | MEANS ($\bar{X}_t$) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | M | F | M | F | M | F | M | F | ($\bar{X}_{tt}$) |
| N-L | Sex | 70.5 | 64.7 | 60.6 | 57.9 | 62.8 | 62.1 | 64.6 | 61.6 | 63.1 |
| | $\bar{X}_t$ | 67.5 | | 59.5 | | 62.4 | | | | |
| L | Sex | 64.3 | 60.2 | 61.3 | 68.2 | 68.6 | 55.8 | 64.4 | 61.4 | 63.4 |
| | $\bar{X}_t$ | 62.6 | | 64.9 | | 62.8 | | | | |
| | | 67.4 | 62.4 | 60.9 | 63.0 | 65.7 | 58.9 | | | |
| MEANS ($\bar{X}_{tt}$) | | 65.0 | | 62.2 | | | | 64.8 | 61.8 | 63.3 |

A. SIXTH GRADE (N = 462)

| | | F | | F-C | | C | | MEANS ($\bar{X}_t$) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | M | F | M | F | M | F | M | F | $\bar{X}_{tt}$ |
| N-L | Sex | 65.1 | 56.2 | 62.4 | 60.8 | 64.9 | 64.7 | 64.1 | 60.6 | 62.6 |
| | $\bar{X}_t$ | 61.4 | | 61.6 | | 64.8 | | | | |
| L | Sex | 69.4 | 62.8 | 63.3 | 66.0 | 69.2 | 64.7 | 67.4 | 64.5 | 66.0 |
| | $\bar{X}_t$ | 65.9 | | 64.9 | | 67.1 | | | | |
| | | 67.2 | 59.5 | 63.1 | 63.4 | 67.0 | 64.7 | | | |
| MEANS ($\bar{X}_{tt}$) | | 63.7 | | 63.3 | | 66.0 | | 65.8 | 62.7 | 64.3 |

B. EIGHTH GRADE (N = 439)

classrooms were quite consistent, even with different orientations to the sunlight. In each classroom where tests were administered, light measurements were made near the windows, near the wall away from the windows, and in between. A Weston Master II lightmeter measured reflected light from the white (90% reflectance) side of a "Kodak Neutral Test Card." The lighting in the classrooms used for testing purposes was within recommended tolerances for material viewed by reflected light and was acceptably consistent from school to school (Terlouw, 1956).

Ambient light present in the rooms used for projection purposes was also remarkably uniform. Most of the rooms were darkened by drawing light-proof drapes, a method which permitted some light to leak in around the sides and bottom of the drapes. Only the rooms used at two of the elementary schools could be completely darkened. However, the ambient light in the drape-darkened rooms could not be measured by the Panavision Brightness Meter[1] focused upon the screen that was used; therefore, the ambient light present in the projection rooms was not considered to be objectionable.

*Sound*. A General Radio Sound Level Meter[2] was used to measure direct sound produced by the projection system during the film showings. Controls employed to minimize ambient sound included admonitions to students being tested and students on the grounds outside the testing rooms not to talk during the test period; admonitions to the experimental groups prior to the film showings not to talk during the showing or while in transit to the testing rooms; and location of the projector as far from the last row of students as space, image size, and image brightness would permit.

Ambient noise levels, room empty, ranged from 55 decibels to 64 decibels. During the sampled test periods, the sound level in the testing rooms rose an average of 8 decibels from Part I to Part V of the test. The noise produced by the projector when running was measured at 62 decibels with the meter held vertically, six feet in front of the projector on the projection axis. Sound produced by the loudspeaker was measured in the same fashion, and was adjusted for each showing to a consistent level of 86 decibels.

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[1] Panavision Brightness Meter, Serial #0291; Licensed by the Motion Picture Research Council; manufactured by Panavision, Inc., Los Angeles, California; primary scale 0-30 footlamberts.

[2] General Radio Sound Level Meter, Model 1555A, 50-100 decibels when measured on the C (linear) scale. Mean sound levels were determined by judging symmetry of needle-swing around zero on the meter.

This sound level seemed slightly high in live projection rooms and slightly low in sound-treated rooms. Compensation for these variations was made by adjusting the treble tone control downward in the live rooms thus reducing the apparent sound level. This procedure was developed during the test tryouts, where no student, when asked, reported difficulty in understanding or hearing the narrator.

Inside Temperatures and Outside Weather. Although very little control could be exercised over these elements in the experimental environment, records were kept so that any major deviations could be identified. Mean room temperatures for all schools during the film showings and the immediate and four-week tests ranged between 70° to 76° with a maximum change of only 3° from the start to finish of any one showing or test. These measures were taken using an Eastman Kodak darkroom thermometer as a reference. The measures made during film showings were taken using the Kodak thermometer. Thermometers associated with the heat-controlling thermostats located in each classroom were used for taking measures during the test periods.

Since the students had to move from projection room to testing room by going outside the buildings, and since any major change in the weather might conceivably affect the results of the study, records were also kept of the weather during the days on which the films were shown and the tests were given. During the four days when the films were shown and the tests were given, the weather was quite stable with a mean temperature of 68.8 degrees, mean humidity of 64.4, and mean barometric pressure of 29.4. On the day of the four-week test, all groups were exposed to essentially the same weather as before, but with a somewhat lower temperature (60°). It may be concluded that no major variance in weather was experienced during the experiment.

## Presentation

Controls exercised in the presentation of the films included positive matching of films with groups; standardized seating; standardized projection system including screen size, surface, and location; and consistent procedures for guiding students from the film showings to the test locations and back to their scheduled classes.

Matching Films to Groups. Typical procedure in the sixth-grade classes was for students to arrive at their home rooms as usual, for roll call to be taken, and for instructions to be given about the event to follow, including the room to which they would go next. The home-room groups then separated into film groups and moved to the testing rooms for roll call and a study period, pending their scheduled move into the projection room for the film showing.

The scheduling of the eighth-grade students was designed to mesh with the class schedules, thus minimizing disruption of normal routine. Each teacher was given a schedule. Each student was given a colored card that contained his name, scheduled film time, and test room. A few minutes prior to each showing, each teacher announced that those students with appropriately colored cards would move to the auditorium for the film. On arrival their cards were checked, they were seated, and counted. The projectionist used identical copies of these schedules for positively matching the correct film with the scheduled group. A second set of films was kept readily accessible in case of accident.

Standardized Seating. The relationships between the seated viewers and the screen were based upon the recommendations of the Foundation for Effective Audio-Visual Projection (Eastman Kodak Company, 1957). For "squarish" rooms the standards recommended were: (1) that a matte screen be used; (2) that the front row be located twice the screen width from the screen, and the back row be located six times the screen width from the screen; and (3) that the audience members be seated so that their greatest viewing angle to the center of the screen be no more than 30° off the axis of projection. Accordingly, a small template of the viewing angle was created and used, in conjunction with a scaled plan of each projection room, to locate the precise position of the screen, the audience in relation to the screen, and the location of the projector.

Seats normally used by the students for viewing films in these rooms were used during the experiment. These seats varied in style from benches at one school to a mixture of standard desks and folding chairs at another school. Since these seating arrangements were normal for the students at each school, it was believed that variation in seats used would not contribute significantly to variance among the groups in the experiment.

Standardized Projection System. The initial and deciding factor in controlling elements of the projection system across the schools was the size of the audience for each showing. It was determined that the average audience size for the sixth grade would be 40 and for the eighth grade 80. Using the Eastman Kodak Standard, it was deterined that an audience of 40 would require a minimum four-foot screen and an audience of 80 would require a minimum six-foot screen. These dimensions were used as described above for locating the several audiences with consistent relationships to the screen. These dimensions also determined the required lens sizes, the projection distances, and the resultant image brightness. A spare projector was set up, focused, and kept energized during the entire projection sequence for use as an alternate in case the operating projector broke down between showings. In each projection room the loudspeakers for both projectors were set up directly beneath the screen and in sight of the audience. A minimum brightness of 9 footlamberts was maintained on each screen, in accordance with the recommendations of Terlouw (1956). These measures were taken from the extreme rear right and left of the viewing areas, using the Panavision Brightness Meter and lighting the screen with the projector unmasked and with the projection lamp to be used during the film showing.

Control Schedules. As described above, students were carefully identified with the correct film. In turn, each group of students received identical introductions to the films, each introduction given by the same person. Following the film showing, each group was guided to its scheduled testing room where identical instructions were given for identical tests. Administrative procedures were carefully controlled both by printed instructions for the students in each test and by the briefings and printed instructions given the administrators prior to the testing sequence. Similar procedures were followed for the delayed test. Further details on the actual conduct of these procedures are provided in Section V.

## IV. PREPARATION OF THE STIMULUS MATERIALS

The experimental stimulus materials were color filmographs. A filmograph is a motion-picture with no movements in its visual content: still photographs or drawings are used as primary visual content. These are photographed on standard motion-picture film, usually in the same way as animation, but without the resulting effects of continuous movement; and the visual content is usually supported by an associated sound track.

For this study, six such filmographs were prepared in color. In three of these films, the non-linear versions, the images accumulated on the screen one after another. Each image remained on the screen as the next appeared; the number of images varied as required by the subject matter. Each completed sequence was separated by a brief period of blank, colored screen. In one of these three films, the non-linear/factual, photographs were used exclusively, and the sound track provided principally descriptive narration; in another, the non-linear/conceptual, only graphic symbols were used, and the sound track provided principally explanatory narration; in the third, the non-linear/factual-conceptual, the two styles of treatment were mixed, the sound track varying in emphasis as appropriate.

In the other three films, the linear versions, the images did not accumulate but were presented one after another, each image disappearing as the next appeared. In every other way, each linear film was made to be as nearly identical to its non-linear mate as possible.

### Selection of Subject Matter for the Films

Bases of selection. Two basic criteria, compatibility and feasibility, were used in the selection of subject matter for the stimulus films: the topics had to be compatible with the variables being manipulated, controlled, and measured, and had to be capable of economical expression on film.

The topics selected had to be compatible with apparent requirements for presentation in the multiple-image format. Early in the development of the films it appeared that all subject matter did not lend itself equally to this format, and it was believed that the chosen subject(s) should be representative of those considered appropriate for this mode of presentation. Also, the subject had to be compatible with required variations in the treatment of the content. In order to measure the effects of these variations on learning, the films had to contain adequate factual and conceptual content. Inasmuch as the dependent variable was learning, the content would have to be appropriate for learning by sixth and eighth graders. Finally, their learning would have to be measurable within Bloom's categories of knowledge, understanding and application.

Given reasonable compatibility, the subject matter would also have to lend itself to feasible production in the film medium. Because the budget was limited, the techniques used in production had to be simple and inexpensive. The filmograph was selected because this film form permitted simple, inexpensive still photos and drawings to be presented repeatedly and to be controlled in sequence and length of exposure. Thus the criterion of feasibility also meant that the selected subject matter had to permit graphic treatment using available talent. This final requirement proved to be one of the most difficult to satisfy among those listed. It required a depth of knowledge on the part of the author of the scripts and commensurate knowledge and skill on the part of the graphic designer. This depth of knowledge was reported as a fundamental requirement in similar efforts by others, and proved essential in this study also (Bruner, 1960). Its importance became particularly apparent as attempts were made to shape the conceptual structure of the subject matter in the preparation of scripts and art work.

Selection of computer programming. The search for subject matter was shifted from symbolic systems such as mathematics and language to objects and systems of objects, such as the electronic digital computer, for example. It was believed that members of the sample population would probably not be familiar with the technical aspects of computers. Too, as subject matter, computers and their operation offered both rich factual content and an implicit and very systematic conceptual structure. However, experienced and expert counsel advised that the concepts and processes of automatic computation were among the most difficult subjects to learn at the grade levels of the chosen sample.[1] It became clear, however, that this subject matter warranted further examination in search of an appropriate topic. Intensive review and discussion with several experts in this subject matter finally yielded computer programming as the topic for the films.[2] Whenever feasible, discussions such as these were recorded on quarter-inch magnetic tape and indexed for subsequent use in the development of scripts and texts and in the preparation of publications.

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[1] Opinion expressed by Dr. Warren Pelton, of System Development Corporation, during a personal interview on 2 June 1960. System Development Corporation is a non-profit institution, located in Santa Monica, California, that is working on applications of information science in the public interest.

[2] Personal interviews with Mr. G. Dobbs, Mr. D. Estavan, Mr. J. Koory, Dr. W. Pelton, Dr. M. Robinson, and Dr. W. Shields (all staff members of System Development Corporation) during December, January and February, 1959 and 1960.

Considered in its most fundamental sense, programming has to do with logical organization, with order, with planning sequences of events, and with the flow of these events. Although the concept of "flow" was acknowledged as basic in programming, it was said to be a very difficult concept to learn at the ages of the sample population.[3] The search for means to present this concept led at last to the selection of flow charting, a subsection of computer programming, as a subject matter that met most of the criteria described above.

Referential content. Since flow charting, or flow diagramming, like mathematics and logic, is the process of manipulating symbols according to appropriate rules of procedure, and since the films were to teach applications of these conventions and symbols to problems in the real world, it was felt appropriate to introduce relevant, real-world representations of the flow-charting procedures as they were developed in the films. For example, included as referential content early in the films was the familiar process of preparing a meal, step-by-orderly-step. This sequence served to introduce three symbols used in the flow charting as presented in the film and to relate these symbols to relevant aspects of a familiar process. More complex charting procedures and concepts were appropriately represented by more complex referents. For example, one early sequence, an automobile ride, simultaneously introduced the concept of "looping" (the return of the diagram upon itself pending a decision to proceed) and its referent in the real world: whether to make a decision to return home from the ride or to continue riding. In the factual and factual-conceptual films, photographs were used to supply visual referents, and the sound track alluded directly to these referents. In the conceptual films, and at times in the factual-conceptual films, these visual referents were themselves abstracted and were represented symbolically, while the sound track carried principally explanatory content, with no direct reference to the particular, real-world content seen and heard in the factual and factual-conceptual films. The launching, orbiting and returning a space capsule process was selected as content for the longest referential sequence because it was believed to hold high interest for the audiences, because it provided rich factual content, and because it lent itself readily to flow charting.

This combination of referential and symbolic subject matter thus provided a range of content that could be delivered on several levels of abstraction, could be represented readily in the desired graphic format, and could be measured for knowledge, understanding, and application. Experience had shown high interest at this age level in programming as content (Pelton and Vaughn, 1960; Dobbs, Myer and Perstein, 1960), and the current emphasis in the public media on the romance of rocketry assured reasonable acquaintance by the audience with that subject. Finally, the symbols of flow charting could be easily and quickly drawn by the graphic artist, and current magazines proved to be rich and economical sources of the required pictorial content.

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[3] Ibid.

## Preparation of Scripts

Scripts for the films were developed in several stages: early planning, preliminary drafts and storyboards, preliminary art, experimental 8 mm films, and final drafts. In each of these phases a number of meetings were held with content and film-production specialists. Each formal meeting was recorded on magnetic tape and was indexed for future use in the preparation of scripts and publications.

Early planning. Having selected the general subject matter to be treated, two problems of planning remained: (1) specific elements of subject matter had to be selected, and (2) these had to be arranged to accommodate the experimental design. Successful differentiation of these elements among all six film versions required detailed identification of factual and conceptual content during the planning stage.

Preliminary drafts and storyboards. The scripts were first outlined for general continuity. Then the previously planned elements of factual and conceptual content were fitted to the outlines. Great difficulty was encountered here and in the preparation of the art work in attempts to achieve an acceptable balance between requirements for separating the elements of the variables and requirements for producing meaningful films. Some minor distortion of the medium was inevitable, particularly since it was clear that production decisions had to favor the experimental rather than the professional use of the medium. Wherever such problems arose in any version, the requirements of the experimental control prevailed.

Discussions with content authorities yielded the recommendation that three basic symbols common in flow charting be included, and that these symbols be used in flow charts that would increase in complexity during each film. Several sequences of referential content were suggested and tried, also with increasing complexity. For example, included as referential content early in the films was the familiar process of preparing a meal, step-by-orderly-step. Each of three main steps was represented by a flow-chart symbol: a diamond for deciding (what to eat), a square for doing (preparing the meal) and a circle for stopping (completing the meal). Arrows were used, as in professional practice, to indicate direction of the flow of action. The flow chart of this sequence is shown in

Figure 2. In the factual and factual-conceptual pairs of films

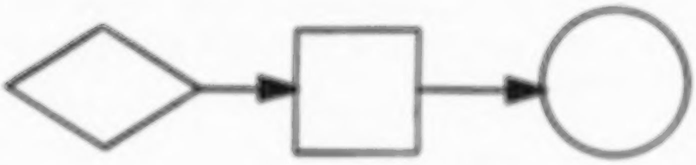

FIGURE 2

BASIC FLOW CHART

it was planned that photographs representative of each step would be flashed on the screen--cumulatively in the non-linear versions and sequentially in the linear versions. In the conceptual films these steps were represented symbolically (by large exclamation points) and were characterized in the sound track as steps in any process.

Later in the films, more complex concepts in flow-charting were introduced implicitly; that is, no direct reference to the new and more difficult procedures was made. For example, in the sound referential sequence (an automobile ride) the very difficult concept of "looping" (the return of the flow process upon itself pending a decision to proceed) was introduced visually, as the sound track identified the vital step in the flow; i.e., making the decision to return home or to keep on riding. No specific reference to "looping" was made in the sound track. This more difficult chart is shown in Figure 3.

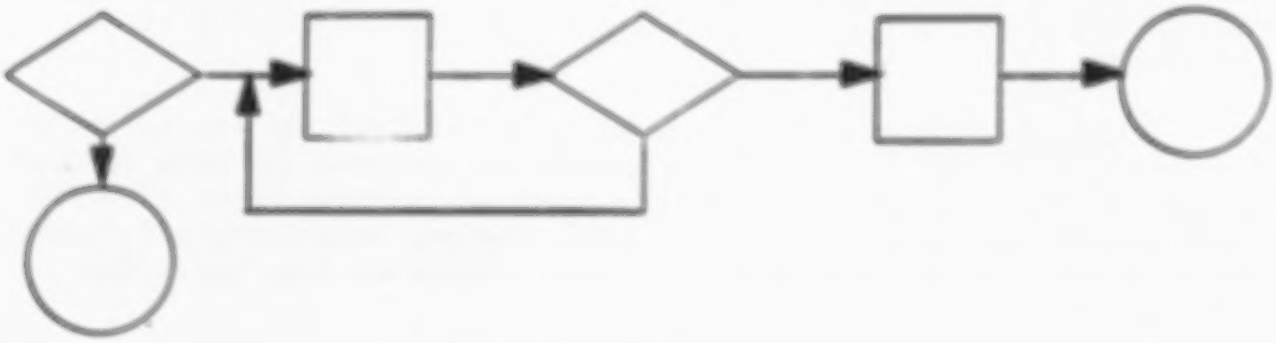

FIGURE 3

FLOW CHART WITH "LOOPING"

The treatment of each of these incremental increases in difficulty was varied for each film according to the requirements of the variables. For example, in the factual versions the processes were described as they happened; no conceptual explanations were included. In the conceptual versions explanations were included and descriptions of real-world processes were excluded. The factual-conceptual versions shifted emphasis back and forth as the content required, thus mixing the two approaches and creating an intermediate version between the two extremes.

Preliminary art. Given the complexity of the total experimental design, and the need for maintaining objective control of production, it was decided to engage professional film producers to create the art work and to produce the films. However, the initial attempt at commercial production failed in the early stages of graphic design. The effort was unsuccessful, not because the film producer could not manage the graphic design or production problems, but rather because the pressures of commercial film production, e.g., schedules, priorities, and interruptions, did not permit sustained effort; and because the habits of commercial creativity, e.g., rapid symbol production and ready acceptance of image-sequences that appeared to "work," were in continuing conflict with requirements for experimental control.

These problems were solved by combining the independent talents of a highly skilled graphic designer and the talents of a skilled animation photographer. Commercial pressures and habits were eliminated in this combination because the designer worked on the project in his leisure time, and the animation photographer worked within the university environment.

With the preliminary scripts in hand and with continuing interpretive guidance, storyboards were finalized by the designer. These graphic summaries were then reviewed for continuity, legibility, feasibility, and adherence to experimental controls. When all preliminary requirements had been met, approval was given for the production of art for several preliminary sequences. These sequences were based upon the non-linear/conceptual version because it was felt that this version would reveal most of the problems of experimental design and film production to be encountered in the other five versions.

Experimental 8mm films. Because it was difficult to estimate the relative effectiveness of the graphic styles and the film formats proposed, these early sequences were shot on 8mm kodachrome film for preliminary evaluation. Rates of image change, image location, image size, number, style, and legibility were estimated from these 8mm test sequences.

Also, a preliminary plan for translating the non-linear versions into linear versions was made based upon these experimental films. It was determined, for example, that each image shown cumulatively in the non-linear version could be shown sequentially in the linear version without seriously compromising the visual integrity of either version. It was also decided that a fixed-frame pattern, as used by Charles Eames in his multi-screened films for the 1962 World's Fair (*Business Screen Magazine*, 1961) would impose unreasonable constraints upon the selection of readily available photographic materials, which were of necessity widely varying in size.

*Final drafts*. During the development of the scripts, a great deal of fitting had been done to ensure parallel structure among the three versions and to achieve a level of difficulty that was consistently appropriate for viewing by the sixth and eighth grade populations. Since the films were not intended to be tests of reading achievement, the language of the scripts was adjusted to be readily understood by the lowest age group. Readability analyses were undertaken scene-by-scene, film-by-film, to provide an index of editorial success (Flesch, 1949). Appropriate changes were made in the final scripts to make these characteristics compatible throughout the films. Totals for the analyses of the three adjusted scripts are presented in Table IV. The reading ease scores placed the scripts slightly lower than the grade level of the sixth-grade groups, and their human interest scores rated them as "interesting" (Flesch, 1949).

When the analyses and adjustments were completed, the final scripts were typed and duplicated for use in recording the narration, preparing the final art, and shooting and editing the pre-test and the final versions of the films (Appendix A).

## *Sound Track*

The scripts were reviewed very carefully in an effort to accommodate the desired effects of art-script interaction, changes were made where necessary, and the scripts were finalized for recording. Each of the three scripts was recorded by the same narrator on magnetic tape, under identical recording conditions, and within what were considered reasonable variances for time and articulation. The lengths of the films in minutes were as follows:

| | Factual | Factual/Conceptual | Conceptual |
|---|---|---|---|
| Non-Linear | 8 min. 5 sec. | 8 min. 0 sec. | 7 min. 42 sec. |
| Linear | 8 min. 5 sec. | 7 min. 58 sec. | 7 min. 40 sec. |

## TABLE IV

## READABILITY ANALYSIS OF SCRIPTS

| Measure | Factual | Factual-Conceptual | Conceptual |
|---|---|---|---|
| Words | 927 | 936 | 926 |
| Sentences | 85 | 92 | 91 |
| Words/Sentence | 10.9 | 10.2 | 10.2 |
| Syllables | 1,248 | 1,266 | 1,232 |
| Syllables/100 Words | 135 | 135 | 133 |
| Reading Ease Score | 82 | 83 | 84 |
| Personal Words | 47 | 47 | 48 |
| Personal Sentences | 17 (20%) | 21 (23%) | 16 (17.5%) |
| Human Interest Score | 25 | 25 | 24 |

Key words were then marked in each script so that they could be identified by frame. The precise frame positions of these words were then recorded on animation shooting scripts for use by the designer in preparing and marking each piece of art work. In this way the art was keyed so that it could be photographed in the proper order and for the proper length of time.

## Final Art

Development of visual materials followed the storyboard very closely. Relationships between script and art had thus been worked out in advance, and the task that remained was one of selecting photographs or creating designs that would expand the storyboard into films of the proper length.

Sequence of production. Art for the non-linear versions was produced first and photographed; then the same art was later rescripted for use in the linear format. Along the other dimension of the study, the conceptual films were produced first, then the factual, and then the factual-conceptual. It was felt that this order would best introduce the graphic designer and photographer to the basic concepts of the study,and would permit orderly re-use of the graphic materials. Also, it was felt that the most difficult problems would be encountered in the production of the non-linear/conceptual version, and therefore this version should be produced first for use in pretesting; however, there was also considerable anticipatory sketching and planning done at the same time for those versions that were to be produced later.

Sources and styles of visual materials. The two conceptual films contained symbolic, non-representational visual materials exclusively. These designs were originated by the graphic designer. The two factual films in the series used colored and black-and-white photographs clipped from national magazines. These clippings were collected in large numbers while the non-linear/conceptual film was in production for pretesting. Thus a wide selection of photographs in several major categories (food, automobile rides, rocket launchings, etc.) were available for use in the preparation of art for the factual versions. The flow charts in all films were drawn using felt pen directly upon the standard overlays of transparent plastic commonly used in the production of animated films. An attempt was made to treat the designs, drawings, and choice of clippings in a style familiar to members of the subject audience.

## Shooting and Editing

In general, the same procedures were followed for shooting and editing all six films. The graphic designer prepared the art work and coded it to match the shooting scripts, as described above in the section on recording. When several sequences had been completed, they were delivered to the animation photographer for shooting. A Richardson-Bowlds animation crane, Model RB-200; a 16 mm Acme Reflex animation camera; Ektachrome commercial color film, type 7255 (reversal); General Electric, 300 watt reflector flood lamps, corrected by custom-made filter to 3200° Kelvin; and standard animation procedures were used for all photography.

Development of exposed film was done by the University of Southern California film laboratory using standard Eastman procedures. Work prints were edited to fit the sound track, and were reviewed using sound-picture interlock in order to provide a final check on the over-all production sequence, and, in the pretest film, to provide guidance for improvements in the final films. Experimentation in design continued during production of the pretest film only.

## Pretesting

The initial version of the achievement test to be used in the experiment was developed in parallel with the films. Thus the pretest audiences for the non-linear/conceptual film also provided the tryout samples for the measuring instrument. Discussion of the conditions and results of these tryouts of the achievement test is presented below in the section on the measuring instrument.

Since it was possible that major changes in the other five films might result from pretests of the non-linear/conceptual film, production of the remaining films was suspended pending completion of the pretests. Also, to reduce costs and to be prepared for anticipated changes, magnetic rather than optical sound track was used on this one film.

Only minor errors were discovered in the film during two pretests. For example, inaccuracies in the flow-charts had been introduced inadvertently by the designer and had not become obvious until the completed film had been reviewed by an experienced computer programmer. Such errors were corrected in all verions of the films. Subjective questions were asked of audience members in the second pretest in order to assess specific characteristics of the film. In general, members of the audience enjoyed the film, did not feel the images changed too fast, and could hear and understand the narrator clearly.

## Final Production

Procedures used successfully in the production of the film for pretesting were followed during the final production of the other five films. As described above in the section entitled "Final Art," the three non-linear films were produced first: conceptual, factual, and factual-conceptual respectively; then the corresponding linear versions were produced in the same order, using the same art work. When the films had been edited, they were reviewed using interlock as a final check before printing. Two prints of each version were made for the experimental phase of the study, one for projection and the other for use in case difficulties were encountered during projection.

PRECEDING PAGE BLANK-NOT FILMED

## V. THE MEASURING INSTRUMENT

A five-part test consisting of 64 items and 92 responses was developed in parallel with the design and production of the six stimulus films. The synchronous development of these two elements of the experiment permitted continuing interactive influnce of one upon the other. The test was prepared to assess relative achievement in learning by each member of the sample population as a consequence of having seen one of the six films.

### Validity

Since the test used in this experiment was based directly upon the visual and verbal content of the films, the relevance component of the test's validity was defined in terms of the functional relationships between the content of the stimulus (the films) and the content of the instrument for recording selected responses to the stimulus (the test).

The test measures were analyzed for reliabilities of internal consistency and test-retest stability. Internal consistency was calculated using the scores produced by the two tryout populations and the scores produced by the entire experimental population. For these calculations, the Kuder-Richardson formula #20 was used (Guilford, 1956). This formula was coded into a program for use on a Philco 2000 computer. The coded computer program was then checked for accuracy by using published data in the machine calculations and then comparing the calculated with the published results. The program worked perfectly.

Results of a computer analysis of collected data showed the estimated reliability of the first tryout measures to be .80, and of the second, .92. Estimates of internal consistency for the final test are reported in Table V. Stability of the measures over time were calculated by correlating the test scores that were produced immediately following the film with the scores produced by the same population in response to the same test four weeks later. Thorndike warned that memory of the items might inflate the coefficients, and that negative attitudes and reduced motivation might "operate to lower the correlation between the two testings" (Thorndike, 1951). In consideration of this warning, it was believed that a four-week interval between administrations of the test and the length of the test would tend to reduce the effects of memory, and that appropriate control of the conditions of testing would tend to reduce the variance due to changed attitudes and motivation. The test-retest coefficients of correlation for the smaller, delayed-test population by grade are reported in Table V. Coefficients were also calculated and plotted for each of the film groups in the sixth and eighth grades separately and in combination. These data are reported

## TABLE V

## RELIABILITY OF FINAL TEST MEASURES
(COEFFICIENTS OF INTERNAL CONSISTENCY
AND OF TEST-RETEST CORRELATION)

| Subtests | II-IV | | | II-V | | |
|---|---|---|---|---|---|---|
| Grade | 6 | 8 | 6+8 | 6 | 8 | 6+8 |
| Internal Consistency | .92 | .94 | .92 | .93 | .93 | .94 |
| Sample Size | 462 | 439 | 901 | 462 | 439 | 901 |
| Test-Retest | .86 | .87 | .86 | .89 | .89 | .89 |
| Sample Size | 421 | 415 | 836 | 421 | 415 | 836 |

in Appendix C. Correlation techniques used in these and other analyses are described in Section VI below.

## Development

Formulation of the test was initiated only after preliminary drafts and storyboards of the three scripts had been completed. Pretryout assessments of early items were then undertaken by a committee of eight specialists. Based upon the committee's recommendations, an early version of the test was compiled and used with the non-linear/conceptual film in the first tryout. The test was scored, assessed for difficulty and clarity, analyzed for reliability, and modified for a second tryout. Procedures for administrative and experimental control were finalized and used in the second tryout. Again the tests were scored, assessed, analyzed, and modified for final publication and use in the experiment.

Formulation. Content to be treated by the test items was drawn from the preliminary lists and diagrams of concepts and processes that were prepared for drafting the scripts. This content was arranged into four subtests for the first two tryouts, and a fifth subtest containing subjective questions was added to the final version of the test. The three primary subtests, Parts II-IV, were based upon Benjamin Bloom's classification of educational goals and were designed to measure knowledge, comprehension, and application in that order (Bloom, 1956). It was felt that by so doing, the generality of the results of the study would be increased and would be appropriately related to known educational objectives. The fourth part of the two tryout tests was addressed specifically to the descriptive content of the factual and factual-conceptual films. Within each subtest the items were arranged in order of increasing difficulty as judged initially by the item writer and subsequently as suggested by the results of the tryouts.

Several rather fundamental procedural guidelines were followed in developing the items. The form of the items was varied to include both subjective and objective types in an effort to elicit unique responses and at the same time to provide data that could be treated statistically. Also, since the tests were to be scored by hand, items had to be designed that could be interpreted and scored within reasonable time and with minimum bias and error. The items were also designed to limit overlap of coverage and cues; for example, the content of one item was not to provide the answer to another. The assumptions of the statistical analysis for reliability (Guilford, 1956; Thorndike, 1951) and the desire to reduce differences in scores as a result of guessing established the time limits of the test to be those of a power test rather than of a speed test; that is, the test should be scheduled to permit from 75% to 90% of the students to try all of the items. To help solve the problem of overlap and to help minimize temptations of student to speed, each subtest was completed and timed separately.

Pre-tryout evaluation. In order to provide objective guidance for categorizing the items into the subtests, and in order to provide expert assessment of the items for their accuracy and technical merit, items were reviewed by a committee of seven specialists drawn from relevant subject fields.[1] It was expected that the diverse specialties of the judges would result in low inter-analyst consistency, but it was also believed that the diversity would yield better criticisms and thus better items than if the specialties of the judges were uniform.

A packet of dittoed materials was devised containing an abstract of the study, a descriptive abstract of Bloom's three categories, one copy of each of the three scripts, one complete set of the draft items (randomly ordered), eight rating sheets, and instructions for proceeding. On the day selected for evaluation, a meeting was held with each judge individually. The materials were explained and the same storyboard was interpreted to each judge. The judges were then left to review the materials, to make records of their estimates, and to call the experimenter if there were any further questions.

The judges were asked (1) to assign each item to one of Bloom's three categories (knowledge, comprehension, application), (2) to rate each item for its ability to discriminate within its assigned category, and (3) to recommend improvements. Data collected on requests numbered two and three were used to guide modifications made in the items. Data from the first request were analyzed using a specially developed coefficient of agreement for the classification of one item into one of three categories by seven judges.[2] In column one of Table VI, it may be seen that there are eight such distributions. In establishing these patterns, no distinction was made between 4,2,1, and 2,4,1, or 1,2,4, and so on. The eight distributions were ranked in order of agreement. If, for the $j^{th}$ distribution, the frequencies for the three categories are $f_{1j}$, $f_{2j}$, and $f_{3j}$, respectively, then the number of ways pattern

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[1] Dr. Leroy Burwein, social psychologist; Mr. Guy Dobbs, senior computer programmer; Dr. Barry Jensen, educational psychologist; Dr. Robert Meeker, psychometrist; Dr. Myron Robinson, systems analyst; Dr. Miles Rogers, psychometrist; Dr. William Shields, operations analyst and mathematician. These men were all staff members of the System Development Corporation, Santa Monica, California.

[2] Developed by Mr. Donald Estavan of System Development Corporation, Santa Monica, California.

## TABLE VI

## DISTRIBUTION OF RATING PATTERNS

| Pattern | $p_j$. Prob. | $P_j$. Cum. | $Q_j$. Agr. | Freq. |
|---|---|---|---|---|
| 7,0,0 | .001 | .001 | .999 | 3 |
| 6,1,0 | .019 | .020 | .979 | 11 |
| 5,2,0 | .058 | .078 | .922 | 8 |
| 5,1,1, | .058 | .136 | .864 | 4 |
| 4,3,0 | .096 | .632 | .768 | 9 |
| 4,2,1 | .288 | .520 | .480 | 5 |
| 3,3,1 | .192 | .712 | .288 | 2 |
| 3,2,2 | .288 | 1.000 | 0.000 | 0 |

j may be obtained is

$$w_j = \left(\frac{7!}{f_{1j}!\,f_{2j}!\,f_{3j}!}\right)\left(\frac{m(m+1)}{2}\right) \quad ,$$

where m is the number of distinct digits in the $j^{th}$ pattern. For example, in the distribution 6,1,0, there are three distinct digits, and in 5,1,1, there are two. The probability of observing any particular j, then, is

$$p_j = \frac{w_j}{\begin{array}{c} 8 \\ w_i \\ i = 1 \end{array}}$$

The probability of occurence, $p_j$, for each distribution is shown in column two of Table VI. Column three of this table gives the cumulative probability, $\hat{p}_j$, of obtaining the given pattern, or one of greater agreement, on the basis of chance alone. The complement of this probability

$$q_j = 1 - \hat{p}_j$$

constituted the coefficient of agreement for the single item for which the judgments were distributed as pattern j. In column four is shown the frequency of occurrence of each pattern of judgment. Because the frequency distribution of $q_j$'s was skewed, the median $q_j$, Q, was used as the over-all measure of agreement. Based upon the 42 items judged by every judge (three items were not judged by all seven), the coefficient of agreement, Q, was found to be .92. This coefficient was believed to indicate that the judges were very consistent in their interpretation of instructions and items.

Ratings and recommendations of the judges were used to modify the items where necessary. Their categorization of items guided the construction of the subjects. The test was then redittoed for use in the first tryout.

First tryout. A single school was selected that had two sixth grades and a total of 63 students from the same school-system population to be used in the final experiment. One hour in advance of the film showing, the projector, loudspeaker, screen, and chairs were set up in accordance with the controls to be used during the final experiment. The projector used was a Bell and Howell model 302 equipped to accommodate the magnetically recorded sound track of the tryout film.

The same presentation and test procedures used in the final experiment were employed in the tryout. In addition, however, the groups were interviewed in order to obtain information for inclusion in the subjective part of the final test.

The computer analysis of the results of the tryout included calculation of the reliability of the measures made by the test, the per cent of the sample that passed each item, and the total score made by each student. Since the lower percentages occurred most frequently, it was concluded that many of the items were too difficult. These data were used to guide the modifications that were made in the test. These revisions included simplification of some items, addition of fifteen responses, clarification of ambiguities detected while scoring the tests, and development of a subjective subtest. It was believed that changes made in the test and the administrative procedures were sufficiently extensive to require a second tryout.

Second tryout. Essentially the same administrative procedures used for the first tryout were also used in the second tryout. The sixth-grade classes were selected from another elementary school of the same population to be used in the final experiment. Projection facilities at the school permitted these classes to see the film as a single group of 72 students. After the film showing, this large group was again separated into two groups for testing. In addition, records were kept of the time needed to complete each part of the test in order to determine the time requirements for the final test.

Analyses for estimating reliability showed that the coefficient of internal consistency had risen from .84 in the first tryout to .92 in the second tryout. Data on proportion passing each response were again summarized and showed a desirable shift from relatively high difficulty of the items in the first tryout to a more normal distribution in the second tryout.

These data and insights, gained during the interview and scoring experiences, yielded several tentative conclusions and suggested some that modifications and additions needed to be made in the final form of the test. It became clear during the interviews that the students had previously developed a strong expectation and preference for movement in the films. They were unfamiliar with, and expressed mild impatience with the filmographic style of presentation. Interestingly and unaccountably, when asked to complete or draw flow-charts, the students in both tryout groups had a strong predilection for drawing connecting lines between the last symbol of the flow charts and the first. Finally, there was clearly time and need for more items, and some existing items required minor changes to remove ambiguities. Seven items were devised and introduced as Part I of the final test; and ten multiple choice and one completion item were added to the test, making a total of twenty new responses added for a total of ninety-two in the final test.

Final test. Both the frequency distribution of percentages of the population passing each response and their scores closely approximated the second-tryout distributions. An attempt was made in revisions prior to publication to anticipate the differential responses of the older segment of the experimental population. This effort was successful, since the desired distributions of the second tryout were sustained with the heterogeneous experimental population.

## Publication

A copy of the final test as it was published and used may be found in Appendix B. A total of 2400 copies of the test were printed on sixty-pound offset paper in booklet form.

## Instructions

Several types of instructions were developed for use in the conduct of the experiment. In general they were required for orientation, transition, and control, and were also used for keeping records.

Instructions for viewing the film. During each of the tryouts, the Principal of each of the two schools gave impromptu introductions and encouraged the students to cooperate. This instruction was followed by a rather close oral rendering of the instructions to the subjects (Appendix B).

Instructions for the test. Directions to be read aloud to the students were kept as brief and direct as possible (Appendix B).

It was found during the tryouts that the students needed better guidance for marking their tests. Test administrators were thus instructed to put the first and third items of Part I on the chalkboard sometime prior to the beginning of the test period. These two items were later read aloud, and the models on the board were used for demonstration.

The instruction sheets were also used to serve several other purposes. Instructions for the test given immediately following the film contained a list of five questions to be used as a basis for discussions about the films after the test was completed. Also included in these instructions was a "Group Data Sheet" to be used by test administrators for recording times and temperatures. Scheduled times and estimated times were provided on this data sheet. For the delayed test these data were to be recorded directly on the sheet of instructions, no additional sheet was necessary.

Instructions to test administrators. In addition to specific instructions guiding the administration of the tests, materials were also prepared to aid in scheduling the tests and in orienting the test administrators to these schedules and to their tasks.

Instructions for scoring. It was considered crucial in scoring the tests that common criteria and procedures be followed. A set of instructions was prepared specifying the steps to be taken while scoring. In addition, a scoring key (Appendix B) and sample score sheet were provided. These materials were to be reviewed carefully by the experimenter for each scorer and were to be used by the scorer in the presence of the experimenter. The intent was to reduce errors and to minimize bias that might be introduced by the scorer were he not so guided.

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## VI. CONDUCTING THE EXPERIMENT

The procedural details followed in conducting the experiment are reviewed in this section: the procedures, the preparation of the data, and the statistical analysis.

### A. PROCEDURES FOLLOWED

Many elements of the experiment have been discussed developmentally in previous sections. These discussions were restricted necessarily to particular elements of the experimental structure and were left inadequately related to that continuous and coherent series of events, the experiment. These events are reviewed in three phases: pre-stimulus phase, stimulus and test phase, and post-test phase.

#### Pre-stimulus Phase

Arrangements. Before the films were shown to the subjects, a variety of administrative, technical, and logistical matters were arranged for and confirmed. The intent and procedural requirements of the experiment were reviewed by the Superintendent of the Fullerton School District, and approval for access was passed on to the Principals of the several schools that would participate. Final approval for access was contingent upon the availability of facilities and the compatibility of schedules as determined by the Principal of each school involved. Each Principal was approached in turn, the intent and procedural requirements of the experiment were reviewed, and tentative schedules were arranged. Requirements for facilities were examined in some detail. Several days in advance of the initial film showings, each of the Principals was contacted again; dates and times were confirmed, and final arrangements were made for the use of their facilities. At this time also, duplicate sets of equipment, including tools for minor maintenance and film repair, were acquired from the Audio-Visual Services section of the Department of Cinema, University of Southern California. Check-lists were drawn up to be used in the final review of preparedness before moving to the site of the initial showings and testings.

Preparations on Site. The arranged schedule called for arrival at the school one hour in advance of the first film showing. Upon arrival, contact was made with the Principal, final arrangements were made and the schedules again reviewed. During that hour the projection equipment was set up as planned; initial measures of screen brightness, levels of reproduced sound, ambient sound, and temperature were taken; a briefing was given to the test administrators as necessary; and the films were carefully checked against the schedules.

In parallel with these technical arrangements, students were reassigned from their home rooms or their scheduled classes to the testing rooms where roll call was taken by the teachers assigned to the experimental groups. In the sixth grade this was done once, and the students used the time available, pending their particular film showing, as an informal study period. In the eighth grade the transitions were initiated on cue from the teachers of regularly scheduled classes; the students then moved to the film showing according to schedule and according to the color of their identification cards.

As the students arrived in the projection room, they were guided to fill the seats from the front to the rear of the room. They were then counted and the count was checked against the expected number as adjusted for absences. In no case was the count different from what was expected.

## Stimulus and Test Phase

These two aspects of the experiment proper included the film showings, an initial test immediately following each showing, and a delayed test given four weeks later.

Film Showings. Each showing was preceded by identical instructions (Appendix B), read by the same individual. The room lights were then turned off, the projector was started, the projection lamp was turned on, and the sound amplification system was turned up to the preset level. When an image appeared on the screen, focus was rechecked, as was the reproduced sound level. Immediately following the film, the room lights were turned on again, and the students were instructed to follow their guide to the room scheduled to receive them.

Test Administration. Upon arrival at the testing room, students were instructed to take their seats quietly. Copies of the test instructions used may be found in Appendix B. Tests and pencils were then distributed, and the first three test items were then reviewed orally by the test administrator. The students were instructed to complete that Part of the test, to record the time on the clock when finished, and then to put their pencils down. The test administrator recorded times and temperatures and monitored the progress of the group. Part two of the test, and the other three Parts were then completed according to instructions.

When the tests had been completed, they and the pencils were collected, the room temperature was taken, and the tape-recorder, brought to each test room in advance, was turned on to record the discussion to follow. Each test administrator, using the questions listed at the end of his instruction sheet, then conducted a discussion with the students for the duration of the scheduled test period.

Procedures followed during the delayed test, given four weeks later, were essentially the same as those for the immediate test, with several minor exceptions. Of course the films were not shown again. Students were tested in their normal classroom environment, no randomization being necessary; and the tests were now administered by their own teachers, the teachers no longer being needed as guides and monitors of randomly mixed groups of students. The teachers, already quite familiar with the experimental procedure desired, were briefed before the tests were given to be sure there was clear understanding of what was to be done.

### Post-test Phase

Transition from Test to Class Schedules. Disruption of class schedules in the sixth grades was minimized by scheduling the showings and tests to occur between the beginning of classes and normal recess, or between recess and the cessation of classes either for lunch or for the end of the school day.

The combined length of the film showings and the tests synchronized perfectly with the scheduled changes of classes for the eighth grade students. Thus transition back into classes simply meant, "Proceed to your next scheduled class."

Collecting Weather Data. Information about the weather during each of the test days was collected to confirm the observations on temperature and light made by the researcher and test administrators, and to establish that no major deviation from normal weather were experienced during the film showings or the administration of the tests. Since local newspapers did not provide detailed information, inquiry was made to the Los Angeles office of the United States Weather Bureau.

## B. PREPARATION OF THE DATA

### Recording the Test Scores

In preparation for scoring, test booklets used immediately after the film were grouped into twenty-four sets corresponding to the twenty-four rooms in which the tests were administered. Booklets used four weeks after the film were grouped into twenty-eight sets corresponding to the twenty-eight teachers who administered the tests. The fifty-two sets of test booklets, totalling some 2,000 tests to be scored, were assigned randomly among four scorers.

A "scorer's kit" was prepared to accompany the sets of booklets. The kit included a set of instructions, a sample manuscript sheet, appropriately labeled, pads of manuscript paper, and an appropriately marked test booklet to be used as a scoring key. Prior to use by the test scorers, these materials were used independently by three people to score the same sample set of booklets. Slight differences in scoring were readily traceable to ambiguities in the instructions and were easily remedied. When test booklets were delivered to each scorer, oral instructions were given by the experimenter in addition to those provided on paper, and several test booklets were scored in the presence of the experimenter to ensure conformity.

Scoring was done using 80-column manuscript sheets in accordance with requirements for computer analysis. Each scored response, for Parts II through V, was tallied on the manuscript with a "1" if correct and a "0" if incorrect. Seventy-two columns of the manuscript were used for recording the scores, and the remaining eight columns were used for recording data to be used in sorting the cards that were to be punched from the manuscript.

Accuracy was achieved by scoring one pair of test pages at a time sequentially down through one complete set of test booklets. In this way errors in placing the digits horizontally on the manuscript were minimized.

As sets were completed, test booklets were selected at random from each set by an experimenter and were rescored. The two sets of scores were then compared. If scoring errors were detected, more booklets in the set were rescored. For one scorer, errors were high enough to require complete rescoring by another scorer. The method used for checking showed the estimated error to be less than 0.2%.

## Recording Student Data

Descriptive data collected for each student included: sex, age, language IQ, non-language IQ; and percentile rankings in language, non-language, vocabulary, composition, arithmetic reasoning, and arithmetic fundamentals.

Data missing from the central administration files were searched for in the files of relevant schools. Data still missing for a given student after this search were supplied by inserting the mean score for the film group of which he was a member.

Among the qualitatively descriptive data, i.e., attitude scores, tape recordings of post-test interviews, and open-ended questions, only the attitude scores were given numerical equivalents. A nine-part scale was used to assign scalar measures to the "X's" made by students on the lines of item 3 in Part I of the test. All scores for item 3 were assigned by the same scorer.

## C. STATISTICAL ANALYSES

Because of the primary role of the new procedures introduced by automated analysis of data, it was believed that documentation requirements for the statistical techniques used in the study should be extended; that is, not only should the documentation include the traditional, source-book references, but acknowledgment should also be made of the computer programs that were used to implement the analysis. This section thus briefly characterizes the function and reliability of these programs and then documents the techniques and programs that were used in the study.

### Function and Reliability of Programs

Essentially, there is very little difference between the procedures used traditionally to process data by hand and the procedures incorporated in a computer program for automated data processing; that is, computer programs are used in much the same way in the machine as source-book procedures have been used in the traditional, desk calculator approach. Each step of the analytical process is carefully worked out to accommodate the particular statistical technique and is then coded into the instructional language of the machine to be used.

Once a sequence of instructions has been written according to a particular set of formulae, it is "run" on the machine and checked for continuity and accuracy of instructions. Then the program is used in the computer to process a published set of data, or a manually-solved, simplified version of the data to be analyzed, and the results are compared. These checks for continuity and accuracy establish the initial reliability of the programs. Continued use confirms this initial estimate or leads to corrections. Thus a program that has been in use for some time may be considered to be quite reliable. Changes in the program that make it more efficient or that make it more effective in use are checked out in much the same way. When completed, the program may be used repeatedly and confidently by the same or other researchers.

With care, the program may be--and often is--modified to accommodate the special requirements of a particular study of the idiosyncracies of a particular statistical specialist and thus may yield additional and valuable by-products of the basic analysis. Also, the specialist may improve upon basic analytical techniques by taking advantage of features of his machine or of new technical developments. These programs are then documented in detail and may be made available to the research community through cooperative libraries or by the institution that sponsored the programming effort. Thus the catalogue of available programs provides the researcher with an alternative source of procedures and techniques.

The programs used in this study were created according to the procedures described above by people of acknowledged competence for use on machines of established reliability. Each of the programs contained instructional sequences that were based upon accepted statistical formulations and included innovations and variations introduced by responsible specialists to extend these formulations and to exploit the capabilities of the machines they were using.

## Statistical Techniques and Computer Programs

Three main types of analyses were undertaken in this study: correlation, variance, and factor analyses. An IBM 7090 computer was used in all analyses for which programs are described below. All programs described were written in the FORTRAN and FAP programming languages.

The statistical technique used to calculate product-moment correlation coefficients among the experimental and descriptive variables in the study is described in Wert, Neidt, and Ahmann (1954). Computer programs used in these analyses were prepared by R. L. McCornack, J. A. Trank, and L. T. Villone of System Development Corporation, Santa Monica, California.[1] The multiple regression program was used to determine if the regressions of the covariates on the dependent variable were the same for each film group. This multiple-correlation technique is described in Wert, Neidt, and Ahmann (1954). A program prepared by Tauchi and Hayward of the University of California, Los Angeles (1961), was used to produce coefficients and scatter-plots of intercorrelations between total scores (Parts II through IV) of the immediate and delayed tests (N-836).

Analyses of variance and covariance, as performed, are described in Wert, Neidt, and Ahmann (1954). A mathematical description of the model used in these analyses may be found in Kempthorne (1952). These analyses were used to establish the statistical differences among the experimental variables, to adjust the test scores for differences among the groups in Language IQ and Arithmetic Reasoning, to establish effects upon learning of the time interval between the immediate and delayed tests, and to determine the interaction between the films and the test. The computer programs that were used have been developed by Hayward (1961).

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[1] Documentation for these programs was part of an internal publication series of System Development Corporation and was not available for open publication.

The principal axes factor analysis, described by Harman (1960), was used to select the covariates and to explore the responses of subjects to the test items and to the stimulus films. The computer program for the factor analyses was produced by the Harvard Statistical Laboratory.[2] The principal axes were rotated orthogonally to the varimax criterion, described by Kaiser (1958). Hayward (1961) wrote the computer program that performed this rotation.

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[2] No published documentation.

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# VII. FINDINGS

The results of the experiment are organized into three main sections for presentation: section A contains a preliminary description of the mean scores for the five parts of the test for each grade and also contains a discussion of the correlations among these parts, the ability and achievement test scores, and other descriptive data; section B presents statistical analyses of the immediate, the four-week, and the control-group test scores; and section C contains several other analyses and descriptions of the test results.

## A. DESCRIPTION OF TEST RESULTS

Mean scores, standard deviations, and mean total scores for subtests II through IV, and II through V are presented in Table VII. These data are reported for each film group within each grade as well as for the entire grade and the total population.

### Part I: Attitudes

As may be seen in Appendix B, Part I of the test contained scalar, open-ended, and other items designed to yield qualitative data. These results are presented in section C below along with other related qualitative data.

### Part II: Knowledge

On the "knowledge" subtest (Part II), high mean score for both grades was made by the linear/factual (L/F) film group. Low mean score was made by the linear/conceptual (L/C) group in the sixth grade and by the non-linear/factual (NL/F) group in the eighth grade. This difference in rank among the means suggests a possible interaction to be tested by the analyses of variance. Standard deviations were quite uniform among the groups, though the range of deviations was slightly greater in the sixth than in the eighth grade.

### Part III: Comprehension

Although the differences were small, the NL/F film group for both grades ranked high among mean scores on the "comprehension" subtest (Part III). Notice also that here, as with Part II of the test, the conceptual films did poorly in the sixth-grade groups but ranked in the middle among mean scores for the eighth-grade groups. In both grades these films yielded relatively large standard deviations.

### Part IV: Application

On the "application" subtest (Part IV), the differences among

# TABLE VII

## PART AND TOTAL MEAN SCORES AND STANDARD DEVIATIONS FOR FILM GROUPS, GRADES, AND TOTAL POPULATION

| FILM GROUPS | N | II | | III | | IV | | II-IV | | V | | II-V | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SIXTH GRADE | | $\bar{X}$ | σ | $\bar{X}$ | σ | $\bar{X}$ | σ | $\bar{X}$ | σ | $\bar{X}$ | σ | $\bar{X}$ | σ |
| NL/F | 82 | 8.18 | 2.91 | 9.20 | 3.23 | 15.95 | 6.26 | 33.33 | 11.03 | 6.04 | 3.49 | 39.37 | 13.67 |
| NL/FC | 74 | 8.14 | 2.56 | 9.20 | 3.82 | 16.62 | 6.21 | 33.96 | 11.03 | 5.15 | 3.66 | 39.11 | 13.84 |
| NL/C | 80 | 7.88 | 2.89 | 8.84 | 3.53 | 14.44 | 7.09 | 31.15 | 11.89 | 4.39 | 3.12 | 35.40 | 14.42 |
| L/F | 81 | 8.53 | 2.26 | 9.12 | 2.92 | 16.36 | 5.90 | 34.01 | 9.58 | 6.33 | 3.39 | 40.35 | 12.14 |
| L/FC | 72 | 7.97 | 3.04 | 8.90 | 3.10 | 15.35 | 7.82 | 32.22 | 12.59 | 5.61 | 3.49 | 37.83 | 15.29 |
| L/C | 73 | 7.07 | 2.94 | 8.42 | 3.01 | 12.16 | 7.31 | 27.66 | 11.97 | 4.44 | 2.72 | 32.10 | 13.71 |
| GRADE | 462 | 7.97 | 2.80 | 8.95 | 3.28 | 15.18 | 6.90 | 32.10 | 11.50 | 5.34 | 3.39 | 37.42 | 14.06 |
| EIGHTH GRADE | | | | | | | | | | | | | |
| NL/F | 73 | 8.71 | 2.63 | 11.29 | 3.27 | 19.32 | 6.00 | 39.32 | 10.63 | 7.52 | 3.48 | 46.84 | 13.24 |
| NL/FC | 74 | 9.11 | 2.45 | 10.31 | 2.76 | 18.92 | 5.46 | 38.34 | 9.36 | 6.97 | 3.12 | 45.20 | 11.70 |
| NL/C | 73 | 9.12 | 2.60 | 11.04 | 3.69 | 18.99 | 5.27 | 39.15 | 10.20 | 7.44 | 3.45 | 46.89 | 12.80 |
| L/F | 72 | 9.62 | 2.52 | 11.06 | 3.48 | 20.49 | 5.14 | 41.17 | 9.73 | 7.67 | 3.69 | 48.83 | 12.32 |
| L/FC | 75 | 8.75 | 2.42 | 10.83 | 3.17 | 19.92 | 5.21 | 39.49 | 9.51 | 7.89 | 3.45 | 47.38 | 12.25 |
| L/C | 72 | 8.94 | 2.44 | 11.14 | 3.15 | 19.47 | 4.84 | 39.56 | 9.01 | 7.04 | 3.34 | 46.60 | 11.58 |
| GRADE | 439 | 9.04 | 2.51 | 10.94 | 3.26 | 19.52 | 5.33 | 39.50 | 9.74 | 7.42 | 3.42 | 46.90 | 12.31 |
| ENTIRE POPULATION | 901 | 8.49 | 2.71 | 9.92 | 3.42 | 17.29 | 6.55 | 35.71 | 11.29 | 6.36 | 3.56 | 42.04 | 14.05 |

the means of the sixth-grade groups were somewhat more marked. As in Part II of the test, the conceptual groups did quite poorly; and, although the non-linear/factual-conceptual (NL/FC) group ranked slightly higher, the linear/factual (L/F) group did well. The eighth-grade students saw less difference among the films, and managed quite well with the conceptual versions. In this grade also, the conceptual versions had the lowest standard deviations; whereas in the sixth grade, the factual versions had the lowest standard deviations.

## Part V: Special Test

This portion of the test was designed principally to explore the characteristic effects on learning of those films that contained pictorial and descriptive material. Among the sixth-grade groups, the conceptual versions (containing no pictorial or descriptive material) were clearly not very successful, as was expected; however, interestingly, this was not true in the eighth grade. Among the factual versions, the linear/factual (L/F) version was most successful in the sixth grade and the linear-factual/conceptual (L/FC) in the eighth grade. The non-linear/factual-conceptual (NL/FC) version was least successful in both grades.

## Total Scores

Since Part V was designed for use with only four of the six films, totals of Parts II through V were also applicable to only these four groups. Totals of Parts II through IV, on the other hand, were applicable to all six groups. Interestingly, in both sets of total scores for both grades, the L/F version was most successful. The L/C version was clearly the least successful in the sixth grade, and the NL/FC version was least successful in the eighth grade.

Among all film versions for both grades there were differences detected by the several parts of the test, differences that showed interactions among elements of the main variables. Also, there seemed to be some consistency in the selection of the L/F version as the most effective and the L/C as the least effective. However, clearly the differences reflecting this and other patterns were not large. It seemed appropriate, therefore, that coefficients of correlation be derived in order to establish whether each subtest should be treated separately in the analyses of variance to be conducted, or whether the total scores alone could be used, thus considerably reducing the number of analyses required. If the coefficients of correlation between total scores and scores on subtests were high, then analysis of only the totals would be in order; if they were low, then separate analyses would be warranted.

Table VIII presents these coefficients not only for the part and total test scores for the entire population, but also for ability and achievement test scores and for correlations among these data and age and sex. Examination of the coefficients for the totals of

## TABLE VIII

### CORRELATION COEFFICIENTS AMONG DESCRIPTIVE DATA AND TEST SCORES (N = 901)

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | 1 | 100 | 4 | 89 | 11 | 18 | 22 | 21 | 20 | 22 | -30 | -20 | -16 | -9 | -4 | 6 |
| Sex | 2 | 4 | 100 | 1 | 2 | 7 | -3 | 1 | 11 | 4 | 1 | 4 | -4 | -5 | 4 | -4 |
| Grade | 3 | 89 | 1 | 100 | 20 | 29 | 33 | 33 | 29 | 34 | -18 | -10 | -8 | -1 | 5 | 14 |
| Part II | 4 | 11 | 2 | 20 | 100 | 59 | 67 | 81 | 55 | 79 | 35 | 31 | 43 | 51 | 48 | 48 |
| III | 5 | 18 | 7 | 29 | 59 | 100 | 69 | 84 | 64 | 84 | 36 | 34 | 43 | 57 | 50 | 48 |
| IV | 6 | 22 | -3 | 33 | 67 | 69 | 100 | 95 | 65 | 93 | 36 | 34 | 44 | 58 | 51 | 51 |
| Total II-IV | 7 | 21 | 1 | 33 | 81 | 84 | 95 | 100 | 70 | 98 | 40 | 37 | 49 | 63 | 56 | 56 |
| V | 8 | 20 | 11 | 29 | 55 | 64 | 65 | 70 | 100 | 82 | 34 | 30 | 48 | 59 | 50 | 47 |
| Total II-V | 9 | 22 | 4 | 34 | 79 | 84 | 93 | 98 | 82 | 100 | 41 | 38 | 52 | 66 | 58 | 57 |
| Language IQ | 10 | -30 | 1 | -8 | 35 | 36 | 36 | 40 | 34 | 41 | 100 | 52 | 52 | 53 | 46 | 36 |
| Non-Language IQ | 11 | -20 | 4 | -10 | 31 | 34 | 34 | 37 | 30 | 38 | 52 | 100 | 28 | 37 | 39 | 40 |
| Reading Vocabulary | 12 | -16 | -4 | -8 | 43 | 43 | 44 | 49 | 48 | 52 | 52 | 28 | 100 | 81 | 68 | 56 |
| Read. Comprehension | 13 | -9 | -5 | -1 | 51 | 57 | 58 | 63 | 59 | 66 | 53 | 37 | 81 | 100 | 74 | 68 |
| Arith. Reasoning | 14 | -4 | 4 | 5 | 48 | 50 | 51 | 56 | 50 | 58 | 46 | 39 | 68 | 74 | 100 | 75 |
| Arith. Fundamentals | 16 | 6 | -4 | 14 | 48 | 48 | 51 | 56 | 47 | 57 | 36 | 40 | 56 | 68 | 75 | 100 |

Part II through IV shows a very high .98 correlation with the total of Parts II through V. Also, Parts II, III, and IV correlate .81, .84, and .95, respectively, with the total for Parts II through V. It was believed that these high correlations justified selection of the total scores for Parts II-IV as the data to be used in the analyses of variance.

Also of interest are the incremental increases in correlation among Parts II, III, and IV of the test and the age of the subjects. Also note that Part V of the test correlated higher than other subtests with the sex of the subjects, though even this correlation was negligible. Finally, among the ability and achievement tests, it is of interest that results of the Reading Comprehension test showed the highest correlations with the parts of the test, and that the IQ scores were only moderately correlated with the experimental test scores.

## B. ANALYSES OF TEST RESULTS

Test results were treated separately at the sixth- and eighth-grade levels. Analysis of covariance was used with Language IQ and Arithmetic Reasoning scores as covariates and with sex as a way of the analysis. The six films shown to the sixth-grade subjects were ranked according to the statistical differences in the group scores. Effects of the time interval between the immediate and delayed tests upon remembering were determined by using analysis of covariance, with the immediate test scores included as an additional covariate. Finally, the differential effects upon learning of the film and immediate test treated as combined and as discrete stimuli were established by using analysis of covariance again; this time, data from two control groups that had not received an immediate test were compared with data from two experimental groups that had been tested immediately.

### Analysis of Immediate Test Results

Covariates for the analysis of covariance were selected by performing a factor analysis of the test scores. Interpretation of the analysis of covariance required several additional diagnostic analyses in order to confirm and clarify the results. Statistical differences among the group scores for the individual films were established for the sixth grade using multiple-range tests for significance.

Selection of covariates. Three criteria were used in the selection of covariates for the analyses. The first, and perhaps most important, required that the covariates selected be meaningful in the context of the study to members of the educational community who might be using the reported results. Secondly, since only two covariates were to be used, it was important that one covariate have a large loading on the first factor, and the other covariate have a large loading on the second factor. Thirdly, these two covariates also had to have a low correlation with each other. Examination of Table IX shows that Non-Language IQ and Reading Comprehension had the largest factor loadings on the first two factors. These two also correlated .37, one of the lowest coefficients in Table X. However, it was felt that these two covariates would not be very meaningful to interpreters of the results of the study.

Further examination of Table IX reveals that Language IQ and Arithmetic Reasoning also had large factor loadings, and were correlated .46. It was believed that these two covariates would be more meaningful to interpreters of the study than the earlier choice would have been. Thus the scores of the experimental population on the Language IQ portion of the California Test of Mental Maturity, and the Arithmetic Reasoning portion of the California Achievement Test were selected for use in the analysis of covariance.

Analysis of immediate test scores, Sixth-grade. Two analyses of variance were performed on these data, one with the two covariates and one without. This schedule of analyses permitted estimates to be made of the effects of the covariates upon the unadjusted data. The results of the analysis of covariance are presented in Table XI. The null hypothesis was accepted in all but two cases: the three content variables (F:FC:C in the Table) were significantly different at the 1% level of significance, and the interaction among those three variables and two format variables (NL:L in the Table) was significant at the 5% level of significance. Comparison of these results with the results of the analysis of variance (no covariates) presented in Table XII shows that the significant difference among the content variables was evident without adjustment for the effects of the covariates, but that the interaction between the two sets of variables (content and format) required adjustment before it became evident. The question thus arose whether this significant interaction was uncovered or whether it was introduced by the analysis of covariance; that is, whether or not the covariance adjustments were appropriate.

Since use of the analysis of covariance assumed that the regressions of the covariates on the dependent variable were the same, a multiple-regression analysis was undertaken to determine if this assumption was tenable. The regression coefficients for each of the six film groups and the coefficients used in the analysis of covariance (ANOVCA in the listing below) were as follows:

## TABLE IX

## UNROTATED FACTOR LOADINGS USED AS A BASIS FOR SELECTING COVARIATES APPLIED IN THE ANALYSIS OF COVARIANCE (N = 901)

| Factors / Variables | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Language IQ | .696 | -.471 | -.430 | .329 | -.036 | -.002 |
| Non-Language IQ | .581 | -.705 | .313 | -.260 | .021 | -.016 |
| Reading Vocabulary | .839 | .247 | -.321 | -.262 | -.013 | -.251 |
| Reading Comprehension | .895 | .209 | -.133 | -.168 | -.106 | .312 |
| Arithmetic Reasoning | .872 | .202 | .188 | .137 | .380 | .017 |
| Arithmetic Fundamentals | .810 | .205 | .423 | .213 | -.263 | -.090 |

## TABLE X

## CORRELATION COEFFICIENTS USED AS A BASIS FOR SELECTING COVARIATES FOR THE ANALYSIS OF COVARIANCE (N = 901)

| VARIABLES (1-6) | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Language IQ | 1 | 1.00 | .52 | .52 | .53 | .46 | .06 |
| Non-Language IQ | 2 | .52 | 1.00 | .28 | .37 | .39 | .40 |
| Reading Vocabulary | 3 | .52 | .28 | 1.00 | .81 | .68 | .56 |
| Reading Comprehension | 4 | .53 | .37 | .81 | 1.00 | .74 | .68 |
| Arithmetic Reasoning | 5 | .46 | .39 | .68 | .74 | 1.00 | .75 |
| Arithmetic Fundamentals | 6 | .36 | .40 | .56 | .68 | .75 | 1.00 |

## TABLE XI

## IMMEDIATE TEST RESULTS: SIXTH GRADE, ANALYSIS OF COVARIANCE (COVARIATES: LANGUAGE IQ AND ARITHMETIC REASONING)

| | df | ss | ms | F | Prob. |
|---|---|---|---|---|---|
| Sex | 1 | 11.45 | 11.45 | 0.20 | ---- |
| N:L | 1 | 195.63 | 195.63 | 3.33 | ---- |
| F:FC:C | 2 | 1,200.82 | 600.41 | 10.21 | <0.01 |
| Sex x NL:L | 1 | 44.93 | 44.93 | 0.76 | ---- |
| Sex x F:FC:C | 2 | 202.90 | 101.45 | 1.72 | ---- |
| NL:L x F:FC:C | 2 | 434.36 | 217.18 | 3.69 | <0.05 |
| Sex x NL:L x F:FC:C | 2 | 115.06 | 57.52 | 0.98 | ---- |
| Within | 448 | 26,354.80 | 58.83 | | |

## TABLE XII

## IMMEDIATE TEST RESULTS: SIXTH GRADE

## ANALYSIS OF VARIANCE

| | df | ss | ms | F | Prob. |
|---|---|---|---|---|---|
| Sex | 1 | 82.31 | 82.31 | 0.64 | ---- |
| NL:L | 1 | 288.86 | 288.86 | 2.25 | ---- |
| F:FC:C | 2 | 1,778.64 | 889.32 | 6.92 | $<0.01$ |
| Sex x NL:L | 1 | 139.75 | 139.75 | 1.09 | ---- |
| Sex x F:FC:C | 2 | 180.52 | 90.26 | 0.70 | ---- |
| NL:L x F:FC:C | 2 | 332.25 | 166.12 | 1.29 | ---- |
| Sex x NL:L x F:FC:C | 2 | 575.60 | 287.80 | 6.24 | ---- |
| Within | 450 | 57,835.67 | 128.52 | | |

| Film Groups | Language IQ | Arithmetic Reasoning |
|---|---|---|
| NL/F | 0.36 | 0.11 |
| NL/FC | 0.46 | 0.06 |
| NL/C | 0.43 | 0.05 |
| L/F | 0.32 | 0.06 |
| L/FC | 0.38 | 0.14 |
| L/C | 0.40 | 0.13 |
| ANOVCA | 0.39 | 0.08 |

Based upon the consistencies readily apparent in these data, the assumption was believed to be tenable and the analysis of covariance was accepted as appropriate.

Mean scores for the significantly different content variables may be seen in Table XIII. Clearly, the conceptual films were least successful among the three pairs of films, whether using the unadjusted or the adjusted data. Notice also, that of the film groups seeing the two conceptual films, the group that saw the L/C version did most poorly. This group also received the largest adjustment in its mean score, slightly over one point. Table XIV shows that this adjustment was attributable largely to the group's low mean score for Language IQ. However, in general, the adjustments made in the data by the analysis of covariance were quite small, and the means of the covariates were quite uniform, confirming the success of the random procedures used to assign subjects to the film groups.

Clarification of the interaction between the two sets of variables proved to be somewhat less straightforward. The adjusted mean scores of the three NL film groups shown in Table XIII rank the FC group first with a mean score of 34.01. However, among the three groups that saw the L versions, the F group ranked first with a mean score of 34.48. These different orders of ranking contributed to the significant interaction between the two main variables. In addition, the two formats also yielded quite different mean score in their conceptual versions, with a mean score of 31.04 for the group that saw the non-linear format and a mean score of 28.76 for the group that saw the linear format. These differential mean scores also contributed to the significant interaction between the two main variables in the experiment.

A Duncan's new multiple-range test was undertaken in search of significant differences among the adjusted means for each of the film groups (Table XIII) and in order to rank the films appropriately (Kramer, 1957) this analysis revealed that:

## TABLE XIII

### IMMEDIATE TEST RESULTS: BOTH GRADES, UNADJUSTED AND ADJUSTED MEAN SCORES

### (COVARIATES: LANGUAGE IQ AND ARITHMETIC REASONING)

| | SIXTH GRADE | | | EIGHTH GRADE | | |
|---|---|---|---|---|---|---|
| | N | Unadjusted | Adjusted | N | Unadjusted | Adjusted |
| SEX | | | | | | |
| Male | 235 | 32.56 | 32.36 | 226 | 39.24 | 40.23 |
| Female | 227 | 31.63 | 31.84 | 213 | 39.77 | 40.15 |
| FORMAT | | | | | | |
| NL | 236 | 32.79 | 32.99 | 220 | 38.93 | 39.28 |
| L | 226 | 31.39 | 31.56 | 219 | 40.06 | 39.71 |
| CONTENT | | | | | | |
| F | 163 | 33.67 | 33.69 | 145 | 40.23 | 40.53 |
| FC | 146 | 33.10 | 32.59 | 149 | 38.92 | 39.04 |
| C | 153 | 29.48 | 29.95 | 145 | 39.35 | 38.94 |
| FILM GROUPS | | | | | | |
| NL/F (1) | 82 | 33.33 | 32.91 | 73 | 39.32 | 40.03 |
| NL/FC (2) | 74 | 33.96 | 34.01 | 74 | 38.34 | 39.18 |
| NL/C (3) | 80 | 31.15 | 31.04 | 73 | 39.15 | 38.63 |
| L/F (4) | 81 | 34.01 | 34.48 | 72 | 41.17 | 41.03 |
| L/FC (5) | 72 | 32.22 | 31.12 | 75 | 39.49 | 38.90 |
| L/C (6) | 73 | 27.66 | 28.76 | 72 | 39.56 | 39.25 |
| TOTAL (Groups) | 462 | 32.10 | 32.05 | 439 | 39.50 | 39.37 |

## TABLE XIV

## MEAN SCORES FOR COVARIATES (ANALYSIS OF IMMEDIATE TEST RESULTS):

## LANGUAGE IQ AND ARITHMETIC REASONING (N = 901)

| | SIXTH GRADE | | | EIGHTH GRADE | | |
|---|---|---|---|---|---|---|
| | N | Language IQ | Arith. Reas. | N | Language IQ | Arith. Reas. |
| SEX | | | | | | |
| Male | 235 | 110.40 | 64.77 | 226 | 106.04 | 65.76 |
| Female | 227 | 110.03 | 61.82 | 213 | 104.77 | 62.73 |
| FORMAT | | | | | | |
| NC | 236 | 110.66 | 63.12 | 220 | 104.98 | 62.61 |
| L | 226 | 109.76 | 63.39 | 219 | 105.87 | 65.97 |
| CONTENT | | | | | | |
| F | 163 | 109.77 | 65.03 | 145 | 104.63 | 63.66 |
| FC | 146 | 111.79 | 62.16 | 149 | 105.52 | 63.26 |
| C | 153 | 109.18 | 62.60 | 145 | 106.12 | 65.97 |
| FILM GROUPS | | | | | | |
| NL/F | 82 | 110.35 | 67.48 | 73 | 104.19 | 61.44 |
| NL/FC | 74 | 110.93 | 59.49 | 74 | 103.64 | 61.59 |
| NL/C | 80 | 110.71 | 62.40 | 73 | 107.14 | 64.82 |
| L/F | 81 | 109.19 | 62.56 | 72 | 105.08 | 65.92 |
| L/FC | 72 | 112.68 | 64.90 | 75 | 107.37 | 64.91 |
| L/C | 73 | 107.51 | 62.82 | 72 | 105.08 | 67.12 |
| TOTAL (Groups) | 462 | 110.22 | 63.32 | 439 | 105.42 | 64.29 |

1. The NL/FC group scored significantly higher at the 5% level of significance than the NL/F, the L/FC, and the L/C groups.

2. The L/F group scored higher at the 5% level of significance than the NL/F and the L/C groups.

3. The NL/C group scored higher at the 5% level of significance than the L/C group.

These relationships may be tabulated as follows--the groups indexed across the top scored higher at the 5% level than the groups indexed on the left:

| | NL/ F | NL/ FC | NL/ C | L/ F | L/ FC | L/ C |
|---|---|---|---|---|---|---|
| NL/ F | | 5% | | 5% | | |
| NL/ FC | | | | | | |
| NL/ C | | | | | | |
| L/ F | | | | | | |
| L/ FC | | 5% | | | | |
| L/ C | | | 5% | 5% | | |

Analysis of immediate test scores, Eighth-grade. The same analytical procedures were followed with the test results for the eighth grade as were followed for the sixth grade. The null hypothesis was accepted in each phase of both the analysis of covariances and the analysis of variance. These analyses are reported in Tables XV and XVI respectively. It should be noted, however, that the analysis of covariance revealed a sex difference with an F ratio that narrowly missed significance at the 5% level but that did not appear in the analysis of variance. However, since this difference was not significant at the selected level of significance, further analysis was not undertaken.

The unadjusted and adjusted mean scores on the immediate test

## TABLE XV

## IMMEDIATE TEST RESULTS: EIGHTH GRADE

## ANALYSIS OF COVARIANCE

## (COVARIATES: LANGUAGE IQ AND ARITHMETIC REASONING)

| | df | ss | ms | F | Prob. |
|---|---|---|---|---|---|
| Sex | 1 | 178.47 | 178.47 | 3.68 | ---- |
| NL:L | 1 | 15.52 | 15.52 | 0.32 | ---- |
| F:FC:C | 2 | 246.35 | 123.18 | 2.54 | ---- |
| Sex x NL:L | 1 | 115.54 | 115.54 | 2.38 | ---- |
| Sex x F:FC:C | 2 | 28.59 | 14.29 | 0.30 | ---- |
| NL:L x F:FC:C | 2 | 28.13 | 14.07 | 0.29 | ---- |
| Sex x NL:L x F:FC:C | 2 | 60.34 | 30.17 | 0.62 | ---- |
| Within | 425 | 20.592.66 | 48.45 | | |

## TABLE XVI

## IMMEDIATE TEST RESULTS: EIGHTH GRADE, ANALYSIS OF VARIANCE

| | df | ss | ms | F | Prob. |
|---|---|---|---|---|---|
| Sex | 1 | 23.95 | 23.95 | 0.25 | ---- |
| NL:L | 1 | 144.80 | 144.80 | 1.51 | ---- |
| F:FC:C | 2 | 142.12 | 71.06 | 0.74 | ---- |
| Sex x NL:L | 1 | 80.02 | 80.02 | 0.84 | ---- |
| Sex x F:FC:C | 2 | 82.53 | 41.27 | 0.43 | ---- |
| NL:L x F:FC:C | 2 | 32.93 | 16.46 | 0.17 | ---- |
| Sex x NL:L x F:FC:C | 2 | 129.81 | 64.91 | 0.68 | --- |
| Within | 427 | 40,881.49 | 95.74 | | |

for the eighth-grade subjects are shown in Table XIII. Notice that here, as in the sixth grade, the adjustments are quite small, and that the uniformity of these scores and the achievement test scores shown in Table XIV again confirms the success of randomization in the control of extraneous variables. Notice also that, on the average, eighth-grade subjects scored seven points higher on the test than did the sixth-grade subjects.

Since no significant differences were found among the eighth-grade test scores, no multiple-range tests were made of these results.

## Analysis of Delayed Test Results

Scores derived from tests given the film groups four weeks after the immediate tests were analyzed as before: the sixth and eighth grade results were separated, and adjustments were made for variations in achievement test scores. In addition, a second major analysis of these delayed test scores was conducted using the immediate test scores as a third covariate; thus not only were the achievement test scores normalized for all groups, but so also were the scores resulting from the immediate test. Finally, the test results of the two control groups were analyzed in order to establish the effects on remembering of each film and immediate test as combined stimuli. Each of these analyses reflected reductions in the sizes of film groups due to a total of 65 absences during the administration of the delayed test.

Analysis of delayed test scores, Sixth-grade. As shown in Table XVII, the null hypothesis was accepted in all phases of the analysis except for a significant difference (1%) among the elements of the content variables. The interaction among the content variables and the format variables disappeared during the four-week interval. Examination of the unadjusted and adjusted means shown in Table XVIII readily identifies the conceptual element among the content variables as the likely cause of the significant difference reflected in the analysis. Noteworthy also in the Table is the increase in mean scores over those shown in Table XIII for the immediate test. In general, the incremental increase was the same in all phases, about one and one-third points.

The results shown in Table XVII were not changed when the immediate test scores were added as a third covariate, as reported in Table XIX; however, the level of significance dropped from 1% to 5% in the differences among the content variables (F:FC:C). Again, the conceptual element among the content variables may be seen in Table XX to be the prime contributor to this significant difference, although the adjustment in the means, as a consequence of using the immediate test scores as a covariate, was rather large. Addition of

## TABLE XVII

## DELAYED TEST RESULTS: SIXTH GRADE,

## ANALYSIS OF COVARIANCE

## (COVARIATES: LANGUAGE IQ AND ARITHMETIC REASONING)

| | df | ss | ms | F | Prob. |
|---|---|---|---|---|---|
| Sex | 1 | 10.13 | 10.13 | 0.13 | ---- |
| NL:L | 1 | 170.01 | 170.01 | 2.24 | ---- |
| F:FC:C | 2 | 1,680.96 | 840.48 | 11.06 | <0.01 |
| Sex x NL:L | 1 | 0.25 | 0.25 | 0.00 | ---- |
| Sex x F:FC:C | 2 | 123.97 | 61.99 | 0.82 | ---- |
| NL:L x F:FC:C | 2 | 73.95 | 36.98 | 0.49 | ---- |
| Sex x NL:L x F:FC:C | 2 | 142.39 | 71.20 | 0.94 | ---- |
| Within | 407 | 30,931.08 | 76.00 | | |

## TABLE XVIII

## DELAYED TEST RESULTS: BOTH GRADES (N = 836), UNADJUSTED AND ADJUSTED MEAN SCORES

(COVARIATES: LANGUAGE IQ AND ARITHMETIC REASONING)

| | SIXTH GRADE | | | EIGHTH GRADE | | |
|---|---|---|---|---|---|---|
| | N | Unadjusted | Adjusted | N | Unadjusted | Adjusted |
| SEX | | | | | | |
| Male | 217 | 33.73 | 33.77 | 219 | 40.95 | 40.78 |
| Female | 204 | 33.35 | 33.33 | 196 | 42.78 | 42.97 |
| FORMAT | | | | | | |
| NL | 219 | 34.17 | 34.12 | 212 | 41.39 | 41.94 |
| L | 202 | 32.87 | 32.92 | 203 | 42.26 | 41.69 |
| CONTENT | | | | | | |
| F | 150 | 34.93 | 35.13 | 134 | 42.36 | 42.49 |
| FC | 133 | 35.36 | 34.65 | 143 | 41.21 | 41.47 |
| C | 138 | 30.23 | 30.71 | 138 | 41.91 | 41.51 |
| FILM BROUPS | | | | | | |
| NL/F | 80 | 35.39 | 35.11 | 69 | 41.32 | 42.06 |
| NL/FC | 66 | 35.70 | 35.48 | 72 | 40.81 | 41.96 |
| NL/C | 73 | 31.45 | 31.84 | 71 | 42.04 | 41.79 |
| L/F | 70 | 34.41 | 35.19 | 65 | 43.46 | 42.95 |
| L/FC | 67 | 35.03 | 33.82 | 71 | 41.62 | 40.98 |
| L/C | 65 | 28.97 | 29.55 | 67 | 41.78 | 41.22 |
| TOTAL (Groups) | 421 | 33.54 | 33.49 | 415 | 41.81 | 41.83 |

## TABLE XIX

## DELAYED TEST RESULTS: SIXTH GRADE, ANALYSIS OF COVARIANCE (COVARIATES: IMMEDIATE TEST, LANGUAGE IQ, AND ARITHMETIC REASONING)

| | df | ss | ms | F | Prob. |
|---|---|---|---|---|---|
| Sex | 1 | 1.27 | 1.27 | 0.03 | ---- |
| NL:L | 1 | 4.17 | 4.17 | 0.10 | ---- |
| F:FC:C | 2 | 259.66 | 129.83 | 3.14 | $<0.05$ |
| Sex x NL:L | 1 | 21.48 | 21.48 | 0.52 | ---- |
| Sex x F:FC:C | 2 | 33.39 | 16.70 | 0.40 | ---- |
| NL:L x F:FC:C | 2 | 29.41 | 14.70 | 0.36 | ---- |
| Sex x NL:L x F:FC:C | 2 | 16.09 | 8.04 | 0.20 | ---- |
| Within | 406 | 16,769.79 | 41.30 | | |

## TABLE XX

### DELAYED TEST RESULTS: BOTH GRADES (N = 836), UNADJUSTED AND ADJUSTED MEAN SCORES

### (COVARIATES: IMMEDIATE TEST, LANGUAGE IQ, AND ARITHMETIC REASONING)

| | SIXTH GRADE | | | EIGHTH GRADE | | |
|---|---|---|---|---|---|---|
| | N | Unadjusted | Adjusted | N | Unadjusted | Adjusted |
| SEX | | | | | | |
| Male | 219 | 33.73 | 33.63 | 219 | 40.95 | 41.15 |
| Female | 204 | 33.35 | 33.46 | 196 | 42.78 | 42.56 |
| FORMAT | | | | | | |
| NL | 219 | 34.17 | 33.70 | 212 | 41.39 | 42.07 |
| L | 202 | 32.87 | 33.41 | 203 | 42.26 | 41.55 |
| CONTENT | | | | | | |
| F | 150 | 34.93 | 33.94 | 134 | 42.36 | 41.70 |
| FC | 133 | 35.36 | 34.28 | 143 | 42.21 | 41.82 |
| C | 138 | 30.23 | 32.34 | 138 | 41.91 | 41.92 |
| FILM GROUPS | | | | | | |
| NL/F | 80 | 35.39 | 34.31 | 69 | 41.32 | 41.93 |
| NL/FC | 66 | 35.70 | 34.36 | 72 | 40.81 | 42.11 |
| NL/C | 73 | 31.45 | 32.60 | 71 | 42.04 | 42.26 |
| L/F | 70 | 34.41 | 33.53 | 65 | 43.46 | 41.57 |
| L/FC | 67 | 35.03 | 34.50 | 71 | 41.62 | 41.52 |
| L/C | 65 | 28.97 | 32.17 | 67 | 41.78 | 41.56 |
| TOTAL (Groups) | 421 | 33.54 | 33.58 | 415 | 41.81 | 41.53 |

scores from the immediate test as a third covariate had the effect of equalizing learning achieved by the students during their exposure to the film and immediate test. The analysis was undertaken to detect effects upon learning of the four-week interval between the immediate and delayed tests. The increase in adjusted mean scores shown in Table XVIII (delayed) beyond those in Table XIII (immediate) show additional learning had taken place during the time interval.

Mean scores for the covariates are shown in Tables XXI and XXII, now with the population reduced to 836 because of absences during the delayed test. It is interesting that, in general, the achievement test scores were higher in this selectively reduced population than those shown in Table XIV for the larger, immediate test population, indicating that these absentees were of lower ability and achievement than the total population. No test of the significance of this difference was performed, however.

*Analysis of delayed test scores, eighth grade.* The sex variable, barely missing significance at the 5% level in the immediate test (Table XV) now shows as significant at the 1% level of confidence in the delayed test, Table XXIII. In all other phases of the analysis, using two covariates, the null hypothesis was accepted. Inspection of the adjusted means shown in Table XX for the male and female populations of the eighth grade shows the girls to be superior to the boys on the delayed test. Important here is that these adjusted means include accommodation of differences in immediate test scores. Table XXI shows the males to be superior in Language IQ and in Arithmetic Reasoning, yet in Table XX it may be seen that the males still received an increase in their mean scores on the delayed test. This apparent paradox is clarified by data appearing in Table XXII. There it may be seen that females scored somewhat better on the immediate test (N = 836) than the males, even though they were, as a group, inferior in Language IQ and Arithmetic Reasoning. The adjusted means shown in Table XX included accommodation of these differences in the scores on the immediate test.

Adjustments for the immediate test scores also revealed another significant difference, as may be seen in Table XXIV; that is, an interaction significant at the 5% level between the sex and format variables (NL:L). Mean test scores for these sub-populations are shown in Table XXV. In both unadjusted and adjusted scores on the delayed test, the male population did somewhat better with the linear than with the non-linear format. The female population did better with the non-linear than with the linear format when the scores were adjusted. These reverse effects account for the significant interaction.

# TABLE XXI

## MEAN SCORES FOR COVARIATES (ANALYSIS OF DELAYED TEST RESULTS):

## LANGUAGE IQ AND ARITHMETIC REASONING (N = 836)

| | SIXTH GRADE | | | EIGHTH GRADE | | |
|---|---|---|---|---|---|---|
| | N | Language IQ | Arith. Reas. | N | Language IQ | Arit. Reas. |
| SEX | | | | | | |
| Male | 217 | 110.30 | 64.59 | 219 | 106.18 | 65.85 |
| Female | 204 | 110.87 | 62.90 | 196 | 105.48 | 64.94 |
| FORMAT | | | | | | |
| NL | 219 | 110.69 | 63.75 | 212 | 105.20 | 63.33 |
| L | 202 | 110.45 | 63.79 | 203 | 106.53 | 67.61 |
| CONTENT | | | | | | |
| F | 150 | 109.88 | 64.72 | 134 | 105.40 | 65.46 |
| FC | 133 | 112.39 | 62.92 | 143 | 105.64 | 64.24 |
| C | 138 | 109.59 | 63.56 | 138 | 106.51 | 66.62 |
| FILM GROUPS | | | | | | |
| NL/F | 80 | 110.20 | 67.54 | 69 | 104.86 | 62.83 |
| NL/FC | 66 | 111.76 | 61.27 | 72 | 103.65 | 62.47 |
| NL/C | 73 | 110.27 | 61.84 | 71 | 107.11 | 64.68 |
| L/F | 70 | 109.51 | 61.50 | 65 | 105.97 | 68.25 |
| L/FC | 67 | 113.03 | 64.54 | 71 | 107.66 | 66.03 |
| L/C | 65 | 108.82 | 65.49 | 67 | 105.87 | 68.67 |
| TOTAL (Groups) | 421 | 110.58 | 63.77 | 415 | 105.85 | 65.42 |

## TABLE XXII

## MEAN SCORES FOR THIRD COVARIATE (ANALYSIS OF DELAYED TEST RESULTS): IMMEDIATE TEST SCORES (N = 836)

| | SIXTH GRADE | | EIGHTH GRADE | |
|---|---|---|---|---|
| | N | MEAN SCORES | N | MEAN SCORES |
| SEX | | | | |
| Male | 217 | 32.40 | 219 | 39.36 |
| Female | 204 | 32.11 | 196 | 39.96 |
| FORMAT | | | | |
| NL | 219 | 32.89 | 212 | 39.00 |
| L | 202 | 31.57 | 203 | 40.32 |
| CONTENT | | | | |
| F | 150 | 33.65 | 134 | 40.46 |
| FC | 133 | 33.35 | 143 | 39.00 |
| C | 138 | 29.70 | 138 | 39.14 |
| FILM GROUPS | | | | |
| NL/F | 80 | 33.56 | 69 | 39.26 |
| NL/FC | 66 | 34.27 | 72 | 38.44 |
| NL/C | 73 | 30.92 | 71 | 39.31 |
| L/F | 70 | 33.74 | 65 | 41.74 |
| L/FC | 67 | 32.43 | 71 | 39.56 |
| L/C | 65 | 28.34 | 67 | 33.73 |
| TOTAL (Groups) | 421 | 32.26 | 415 | 39.64 |

## TABLE XXIII

## DELAYED TEST RESULTS: EIGHTH GRADE, ANALYSIS OF COVARIANCE (COVARIATES: LANGUAGE IQ AND ARITHMETIC REASONING)

| | df | ss | ms | F | Prob. |
|---|---|---|---|---|---|
| Sex | 1 | 502.12 | 502.12 | 8.19 | <0.01 |
| NL:L | 1 | 15.31 | 15.31 | 0.25 | ---- |
| F:C | 2 | 129.74 | 64.87 | 1.06 | ---- |
| Sex x NL:L | 1 | 1.27 | 1.27 | 0.02 | ---- |
| Sex x F:FC:C | 2 | 7.18 | 3.59 | 0.06 | ---- |
| NL:L x F:FC:C | 2 | 34.72 | 17.36 | 0.28 | ---- |
| Sex x NL:L x F:FC:C | 2 | 71.03 | 35.52 | 0.58 | ---- |
| Within | 401 | 24,575.75 | 61.29 | | |

## TABLE XXIV

## DELAYED TEST RESULTS: EIGHTH GRADE, ANALYSIS OF COVARIANCE (COVARIATES: IMMEDIATE TEST, LANGUAGE IQ, AND ARITHMETIC REASONING)

| | df | ss | ms | F | Prob. |
|---|---|---|---|---|---|
| Sex | 1 | 208.22 | 208.22 | 7.56 | < 0.01 |
| RL:L | 1 | 44.52 | 44.52 | 1.62 | ---- |
| F:FC:C | 2 | 1.15 | .51 | 0.02 | ---- |
| Sex x RL:L | 1 | 124.56 | 124.56 | 4.52 | < 0.05 |
| Sex x F:FC:C | 2 | 17.18 | 8.59 | 0.31 | ---- |
| RL:L x F:FC:C | 2 | .30 | .15 | 0.00 | ---- |
| Sex x RL:L x F:FC:C | 2 | 16.73 | 8.37 | 0.30 | ---- |
| Within | 400 | 11,010.69 | 27.53 | | |

## TABLE XXV

## UNADJUSTED AND ADJUSTED MEAN SCORES OF EIGHTH GRADE MALE AND FEMALE POPULATION FOR THE FORMAT VARIABLES

| | DELAYED | | | ACHIEVEMENT | | IMMEDIATE |
|---|---|---|---|---|---|---|
| | N | Unadjusted | Adjusted | Language IQ | Arith. Reas. | Unadjusted |
| MALE | 219 | 40.95 | 41.15 | 106.18 | 65.85 | 39.36 |
| NL | 117 | 40.46 | 40.94 | 105.10 | 63.97 | 39.22 |
| L | 102 | 41.51 | 41.16 | 107.41 | 68.01 | 39.51 |
| FEMALE | 196 | 42.78 | 42.56 | 105.48 | 64.94 | 39.96 |
| NL | 95 | 42.53 | 43.47 | 105.33 | 62.54 | 38.73 |
| L | 101 | 43.02 | 41.71 | 105.63 | 67.21 | 41.13 |
| TOTAL | 415 | 41.81 | 41.83 | 105.85 | 65.42 | 39.64 |

Analysis of control-group test scores. Two small control groups were drawn at random from the eighth-grade population, were shown the NL/FC and L/FC films, were not tested immediately, but did receive the delayed test four weeks later. These scores were then analyzed along with the scores of the experimental groups that saw the same films but that also received the immediate test as well as the delayed test. This analysis was done to detect whether or not the immediate test was functioning as a learning experience in combination with the films. The results of the analysis are shown in Table XXVI. The null hypothesis was accepted for the two format variables (NL:L) and for the interaction between those variables and the combined groups having immediate test scores (ITS) and no immediate test scores (NITS). However, the null hypothesis, that there was no difference between the groups that were tested immediately and those that were not, was rejected at the 1% level of significance. Examination of the mean scores for these groups in Table XXVII shows a difference of some five points between the means for the ITS and NITS groups. Notice also that there were only slight adjustments for the covariates, confirming the success of the procedures for randomization that were used to assign subjects to the control groups.

## C. OTHER ANALYSES

Consistent with the exploratory purposes of the experiment, the following section presents materials designed to examine its results somewhat less quantitatively. Although some very sophisticated statistical techniques were used as means, the ends in view for these explorations were to examine qualitatively the more subjective aspects of the experiment. This portion of the section thus reports the results of a factor analysis of the item scores and also includes a review of results from the subjective items in Part I of the test and from interviews held by the test administrators of the film groups at the conclusion of each immediate test.

### Factor Analysis of the Item Scores: Immediate Test

As was described in Section V, considerable care was taken in the development of the measuring instrument for this experiment. A structure was employed in its design that was based upon a well-known taxonomy of education objectives (Bloom, 1956). The subject matter of the stimulus films was carefully sampled and fitted as items into this structure. However, with all this care, the results have shown that when the items were clustered according to the taxonomical logic, the resulting subtests correlated too highly with each other to be considered discrete measures.

# TABLE XXVI

# DELAYED TEST RESULTS: CONTROL GROUPS, WITH NO IMMEDIATE TEST SCORES (NITS), ANALYSIS OF COVARIANCE (COVARIATES: LANGUAGE IQ AND ARITHMETIC REASONING)

| | df | ss | ms | F | Prob. |
|---|---|---|---|---|---|
| NL:L | 1 | 31.86 | 31.86 | 0.54 | ---- |
| ITS x NITS | 1 | 760.68 | 760.68 | 14.12 | <0.01 |
| NL:L x ITS:NITS | 1 | 131.81 | 131.81 | 2.45 | ---- |
| Within | 184 | 9,909.23 | 53.85 | | |

## TABLE XXVII

## DELAYED TEST RESULTS: CONTROL GROUPS
## UNADJUSTED AND ADJUSTED MEAN SCORES
## (COVARIATES: LANGUAGE IQ AND ARITHMETIC REASONING)

| | EIGHTH GRADE | | |
|---|---|---|---|
| | N | Unadjusted | Adjusted |
| ITS | 143 | 41.21 | 41.19 |
| NITS | 47 | 36.51 | 36.57 |
| NL | 95 | 39.48 | 40.09 |
| L | 95 | 40.61 | 40.01 |
| ITS:NL | 72 | 40.81 | 41.68 |
| ITS:L | 71 | 41.62 | 40.69 |
| NITS:NL | 23 | 35.35 | 35.09 |
| NITS:L | 24 | 37.62 | 37.98 |
| TOTAL | 190 | 40.05 | 39.16 |
| | | LANGUAGE IQ | ARITH. REAS. |
| ITS | 143 | 105.64 | 64.24 |
| NITS | 47 | 106.32 | 62.45 |
| NL | 95 | 104.46 | 62.62 |
| L | 95 | 107.16 | 64.97 |
| TOTAL | 190 | 105.81 | 63.79 |

A principal axes factor analysis of scores on the immediate test was undertaken to help clarify the patterned relationships between the items and the subject matter of the stimulus films as they were experienced by the students of both grades; that is, to provide a basis for comparing the structure used in the design of the test with the factorial structure seen by the subjects. The 64 variables used in the factor analysis were the scored responses for each of the 49 items in Parts II,III, and IV of the final test. The latent roots and cumulative per cent of trace for all variables of the first six factors in the analysis were as follows:

| Factors | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Latent Roots | 12.50 | 2.58 | 1.73 | 1.58 | 1.47 | 1.40 |
| Cumulated Trace | 19.53 | 23.57 | 26.27 | 28.74 | 31.04 | 33.22 |

These six factors were then rotated orthogonally to the varimax criterion. Each factor in the resulting matrix was searched for those loadings that had relatively large absolute values. The selected loadings were then ranked and listed in descending order along with their associated response, item, and Part numbers. The results are shown in Table XXVIII.

Clearly, in terms of those responses with high loadings, Part IV dominates the test, comprising the first factor exclusively and predominating in factors three and four. Part III of the test appears predominately in factors two and five. A few items of Part II appear in the fifth factor and predominate in the sixth factor. It must be re-emphasized in this assessment that the six factors were orthogonal. Prior to rotation, the complete first factor (Table XXVIII) shows only the nine responses with high loadings) accounted for nearly 20 per cent of the variance, while the other five factors combined accounted for only 13 per cent. The other two-thirds of the variance was distributed over 58 additional factors. Part IV, therefore, was a very powerful segment of the test; and, interestingly, the nine responses with high loadings in the first factor were accounted for by only three items: two, three, and four.

Examination of items two, three, and four of Part IV of the test (Appendix B) suggests that these items were sampling the subject's ability to relate real-world experiences to the flow-charting

## TABLE XXVIII

## SELECTED LOADINGS FROM FACTOR ANALYSIS OF ITEM SCORES (IMMEDIATE TEST)

| FACTOR | RESP. | ITEM | PART | LOADING | FACTOR | RESP. | ITEM | PART | LOADING | FACTOR | RESP. | ITEM | PART | LOADING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | 41 | 4 | IV | .789 | II | 33 | 18 | III | .589 | III | 53 | 9 | IV | -.650 |
|  | 45 | 4 | IV | .783 |  | 55 | 20 | III | .566 |  | 55 | 9 | IV | -.554 |
|  | 44 | 4 | IV | .719 |  | 56 | 10 | IV | .526 |  | 50 | 9 | IV | -.551 |
|  | 42 | 4 | IV | .697 |  | 64 | 14 | IV | .519 |  | 51 | 9 | IV | -.503 |
|  | 43 | 4 | IV | .664 |  | 32 | 18 | III | .480 |  | 52 | 9 | IV | -.496 |
|  | 39 | 3 | IV | .659 |  | 58 | 12 | IV | .407 |  | 54 | 9 | IV | -.483 |
|  | 40 | 4 | IV | .580 |  | 27 | 13 | III | .401 |  | 20 | 6 | III | -.428 |
|  | 38 | 2 | IV | .565 |  | 62 | 14 | IV | .367 |  | 60 | 13 | IV | -.247 |
| IV | 59 | 13 | IV | .635 | V | 22 | 8 | III | -.520 | VI | 3 | 3 | II | .534 |
|  | 61 | 13 | IV | .602 |  | 15 | 1 | III | -.498 |  | 4 | 4 | II | .527 |
|  | 60 | 13 | IV | .558 |  | 6 | 6 | II | -.446 |  | 2 | 2 | II | .501 |
|  | 62 | 14 | IV | .490 |  | 26 | 12 | III | -.430 |  | 7 | 7 | II | .361 |
|  | 47 | 6 | IV | .489 |  | 21 | 17 | III | -.419 |  | 12 | 12 | II | .335 |
|  | 49 | 8 | IV | .485 |  | 46 | 5 | IV | -.384 |  | 37 | 1 | IV | .329 |
|  | 64 | 14 | IV | .472 |  | 1 | 1 | II | -.374 |  | 38 | 2 | IV | .304 |
|  | 48 | 7 | IV | .430 |  | 54 | 9 | IV | -.361 |  | 16 | 2 | III | -.414 |

symbols and the processes represented. In particular, the students were asked to match cue phrases such as "getting dressed" (item two) with the appropriate symbol. This was believed to be precisely what the stimulus films were designed to do.

Briefly, the remaining five factors were interpreted as follows: the second factor reflected understanding of the concept of flow, that is, sequence or order of events as shown by the symbols and arrows in the charts; the third factor reflected ability to relate relevant verbal labels to a described sequence of happenings; the fourth reflected ability to relate relevant verbal labels to a charted sequence of happenings; the fifth reflected comprehension of the concept of order in a sequence of happenings; and the sixth reflected recollection of the meaning and precise function of each of the symbols.

Assuming these interpretations to be reasonably correct, the structure that was used to partition the items into subtests was supported by the factor analysis.

## Subjective Items: Part I of Immediate Test

The subjective portion of the final test, Part I (Appendix B), consisted of seven items with 13 responses. The first two questions were designed to establish the subject's estimated length of the film. These are shown by film group and grade in Table XXIX. Question one called for selecting one of five estimates varying from very long to very short. The frequency distribution for the total population (N = 901) was as follows:

| | |
|---|---|
| Very long | 0 |
| Long | 23 |
| Medium | 447 |
| Short | 393 |
| Very short | 38 |

Using a five-point scale, calculation of the means was undertaken for each film group, for each grade, and for the total population. The results are shown in Table XXIX. Sixth-grade subjects found the L/F film to be long and the L/FC film short; the eighth-grade subjects found the NL/C film to be long and the NL/F and L/F to be short. In general, this pattern was followed when the students were asked in the second question to estimate the length of the film in minutes, although in the eighth grade the subjects reversed their estimate of the longest film (NL/C) when asked to specify the length in minutes. It is important to emphasize that these differences in question one were slight, of the order of tenths of the distance between three and four on the five-point scale. Both grades estimated the films to be from four to seven minutes longer than their actual eight-minute

## TABLE XXIX

## RESULTS OF SUBJECTIVE QUESTIONS: PART I OF IMMEDIATE TEST

| PART I | SIXTH GRADE (N = 462) | | | | | | | EIGHTH GRADE (N = 439) | | | | | | | N = 901 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| QUESTIONS | NL/F | NL/FC | NL/C | L/F | L/FC | L/C | $\bar{X}$T | NL/F | NL/FC | NL/C | L/F | L/FC | L/C | $\bar{X}$T | $\bar{X}$GT |
| 1 Lgth Flm (w) | 3.34 | 3.42 | 3.39 | 3.51 | 3.28 | 3.32 | 3.42 | 3.52 | 3.65 | 3.75 | 3.61 | 3.51 | 3.67 | 3.62 | 3.52 |
| 2 Lgth Flm (m) | 12.58 | 14.04 | 13.38 | 14.62 | 13.03 | 13.53 | 13.52 | 14.08 | 15.30 | 13.04 | 13.31 | 14.75 | 13.26 | 13.95 | 13.74 |
| 3a Like Film? | 6.40 | 6.11 | 5.64 | 5.60 | 6.06 | 5.38 | 5.85 | 5.36 | 5.50 | 4.45 | 4.97 | 5.65 | 4.36 | 5.05 | 5.45 |
| 3b Learn? | 6.85 | 6.15 | 6.05 | 6.44 | 6.26 | 5.15 | 6.15 | 5.41 | 5.61 | 4.49 | 5.01 | 5.59 | 4.35 | 5.07 | 5.60 |
| 3c Narr. Clear? | 7.36 | 7.16 | 7.01 | 7.09 | 7.36 | 6.32 | 7.05 | 7.33 | 6.91 | 6.15 | 6.96 | 7.68 | 5.9 | 6.82 | 6.93 |
| 3d Narr. Fast? | 5.21 | 5.26 | 5.05 | 5.40 | 5.22 | 5.22 | 5.23 | 5.38 | 5.58 | 5.48 | 5.38 | 5.20 | 5.25 | 5.38 | 5.30 |
| 3e Many Pics? | 5.46 | 5.09 | 5.29 | 5.67 | 5.31 | 6.16 | 5.50 | 5.68 | 5.58 | 6.26 | 5.68 | 5.00 | 5.88 | 5.68 | 5.58 |
| 3f Flow too Fast? | 5.97 | 6.03 | 5.62 | 6.47 | 6.10 | 6.01 | 6.00 | 6.41 | 6.81 | 6.50 | 6.21 | 6.44 | 6.31 | 6.45 | 6.22 |
| 3g Pics.Fit Narr.? | 6.72 | 7.26 | 6.82 | 6.99 | 7.24 | 6.19 | 6.89 | 6.32 | 6.53 | 5.57 | 6.24 | 6.73 | 5.75 | 6.19 | 6.54 |

length. There was a strong tendency to select times in the middle of the range of option (1 to 25 minutes). A slight negative correlation was found between responses to these two questions, as shown in Table XXX.

All parts of question three were scored using a nine-point scale; thus five was the midpoint. There was a tendency for the subjects to mark all the scales slightly to the right of center (Table XXIX), possibly following a pattern that was established by the first three parts of the question. As a test of possible bias in these responses, scales of the second three parts were reversed in emphasis, and the last part was reversed again. The correlation analysis showed a very slight but negative relationship between the second three and the first three parts of this item, suggesting a tendency for the subjects to respond automatically.

Both grades felt that the narration was clear and suited to the pictures. The sixth grade clearly felt it had learned more from the films than the eighth grade and liked the films better as well. The correlation analysis (Table XXX) showed that a substantial relationship existed between these two feelings, and that a definite but small relationship also existed between these enthusiasms and the convictions concerning pictures and narration; however, these were all negligibly related to scores. Consistent with the trend seen in the mean totals for acceptance of the films, age was negatively correlated with feelings about having learned from the films; that is, the younger subjects felt they learned more.

The open-ended questions, 4, 5, and 6 supported these data in a somewhat cryptic manner. The males generally answered these questions in a word or phrase; the females were more articulate. In general, the attitudes of both grades were the same, subjects in the eighth grade being somewhat more fluent and critical in their evaluative remarks.

When asked about the appearance of the screen between sequences (question four), most remembered that the screen was colored when blank. Less frequently, a few ventured an explanation: "Well, since there were no pictures, I could consintrate (sic) more on what was said." Or an opinion was offered: "Dull." Or a point of view was expressed: "The inside of a milk carton." This last comment was typical of a cluster of responses that were clearly attempts to translate precisely what was seen into language; this one, though apparently facetious, was actually quite accurate inasmuch as the light on the screen during these sequences was often filtered through film of a warm hue. Other instances included reference to scratches on the film, grain, color shifts, appearance of paper, and so on. Some subjects saw these films very clearly indeed. However, though there may have been many who saw things in

## TABLE XXX

## CORRELATION COEFFICIENTS (N = 901): ITEMS OF PART I, TOTAL SCORES (PARTS II-IV), AND COVARIANTS (LANGUAGE IQ AND ARITHMETIC REASONING)

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Lgth Flm (v) | 1 | 100 | -25 | -4 | -4 | 4 | 2 | -3 | -0 | -1 | 9 | 1 | 9 | 9 | 17 |
| 2 Lgth Flm (m) | 2 | -25 | 100 | -2 | -2 | -3 | 4 | 3 | 7 | 3 | 2 | -6 | -10 | -3 | 5 |
| 3a Like Film? | 3 | -4 | -2 | 100 | 58 | 27 | -5 | -5 | -7 | 29 | -6 | -2 | -8 | -11 | -11 |
| 3b Learn? | 4 | -4 | -2 | 58 | 100 | 29 | -4 | -1 | -9 | 29 | 3 | 5 | 3 | -10 | -22 |
| 3c Narr Clear? | 5 | 4 | -3 | 27 | 29 | 100 | -18 | 2 | -7 | 26 | 11 | 8 | 5 | -6 | -9 |
| 3d Narr Fast? | 6 | 2 | 4 | -5 | -4 | -18 | 100 | 7 | 21 | -7 | -8 | -5 | -3 | 5 | 10 |
| 3e Many Pics? | 7 | -3 | 3 | -5 | -1 | 2 | 7 | 100 | 20 | 5 | -0 | 7 | 4 | 5 | 2 |
| 3f Flm too fast? | 8 | -0 | 7 | -7 | -9 | -7 | 21 | 20 | 100 | -0 | -3 | -4 | -6 | 5 | 10 |
| 3g Pics fit Narr? | 9 | -1 | 3 | 29 | 29 | 26 | -7 | 5 | -0 | 100 | -1 | 0 | -4 | -1 | -13 |
| TOTALS PARTS II-IV | 10 | 9 | 2 | -6 | 3 | 11 | -8 | -0 | -3 | -1 | 100 | 40 | 56 | 1 | 21 |
| Language IQ | 11 | 1 | -6 | -2 | 5 | 8 | -5 | 7 | -4 | 0 | 40 | 100 | 46 | 1 | -30 |
| Arithmetic Reas. | 12 | 9 | -10 | -8 | 3 | 5 | -3 | 4 | -6 | -4 | 56 | 46 | 100 | 4 | -4 |
| Sex | 13 | 9 | -3 | -11 | -10 | -6 | 5 | 5 | 5 | -1 | 1 | 1 | 4 | 100 | 4 |
| Age | 14 | 17 | 5 | -11 | -22 | -9 | 10 | 2 | 10 | -13 | 21 | -30 | -4 | 4 | 100 |

this detail, few were articulate about their perceptions. Most answered simply "Blank" or "Colored." There were no distinctive differences--except facility with the language--between the sixth and eighth grades on this question.

Question five, concerning which part of the film was liked best, elicited much more comment. By far the largest cluster of responses had to do with the flow chart, its introduction and its use: I liked "where it told witch of the simbles (sic) represented what." The second largest cluster selected the rocket sequences: "Where it explained how the flow chart worked during the time the astronauts took off in space." Many liked an early scene that related the preparation of food to the idea of sequence: I liked the part "about the different steps you have to take to eat. I didn't realize there were so many steps." Others simply answered "beginning," or "middle," or "end." In general, there was preference for action sequences that lent meaning to flow charting.

The sixth question offered an opportunity to criticise the films by asking the subjects what they disliked about the films. The responses were considerably more specific about what they disliked than about what was liked. Repetitiousness received the most criticism: "When they explained the same thing over and over," or, "when it kept showing the three numbers and different shapes over and over again." The use of numbers, "the 1-2-3 part," received particular recognition. The meal-preparation sequence early in the film, "when they were showing the preparing the meal over and over again," also received frequent mention in answer to this question. The males found the blank screen readily mentionable. Some also found the one word "none" to be economical, along with "beginning," "middle," and "end"--though rarely in the same commentary--particularly "beginning." Throughout the comments there were hints of confusion caused by the "flashing numbers and pictures," particularly from the groups that saw the linear versions. The over-all impression from responses to this item was that subjects of both grades were uncomfortable with the films, and that though many were quite specific, most were quite vague in the expression of this discomfort.

When asked in the seventh question whether they had "ever seen a flow diagram before," 833 subjects answered no and 68 answered yes. Previous learning in this subject matter was apparently not a major influence on the results of the study.

### Interviews of Film Groups After Immediate Test

Open discussions with the subjects were conducted by each of the test administrators during the remaining moments of the immediate test period. These exchanges were based upon four questions included in the printed instructions given to each administrator (Appendix B), briefly: How were the films different? What was liked? Disliked? How might the films be improved? As in the written questions, the eighth-grade subjects were cryptic and critical. The males were considerably more communicative during the interviews than they were on the tests; the females were less communicative than the boys in the interview situation. Both groups enjoyed the "brainstorming" character of these sessions, and vied enthusiastically to be heard. Each session was tape recorded on quarter-inch magnetic tape for review later.

Few said they had seen a film "like this" before. Brief inquiry of these claimants showed they were referring to several dimensions of similarity; for example, they cited films with geometric forms, with photographs only, with rockets and so on. It seemed reasonably clear that few if any had seen filmographs, multi-image presentations, or flow charts on film. Upon inquiry about differences between these films and others they had seen, references were made to the blank screen, to the lack of movement, the magazine pictures, the lack of "story"--"this really showed you how to do it rather than have Billy and Bobby doing it"--and to the brevity and simplicity of the films.

When asked what they liked about the films, the enthusiastic consensus was that they had learned something new and quickly, and they liked that. "We learned a lot in a short time." "Most movies are long and you don't learn very much; this one was short and you learned a lot." The narrator "just went right to the point and didn't just set there talkin' (sic)," "...right to the point with no extras," and so forth. Favorable mention was also made of the color, the flow charts, the "drawings like ours" (the flow charts in the films were drawn from hand with a felt pen), and "how it told you about the film before it started."

By far the most popular and emphatic criticism from both grades was directed toward repetition in the films. Another large cluster of critics didn't like the speed with which the pictures changed: "show them a little longer," "too many different kinds of pictures," "pictures not on the screen long enough to see them," and so forth. A variety of comments were made about the narrator, about half critical and half favorable: "narrator talked like he wasn't interested," to be countered by, "I liked the voice of the man talking." The art work was also criticized: "Too many lines," "looked like about ten jigsaw puzzles mixed together," "wasn't a very good printer."

Discussions about improving the film were almost always very enthusiastic. The most frequent suggestion was that the pictures should move. Almost as frequently it was suggested that the films be slowed down: "make it not so jumpy," "leave the pictures on longer," and so on. Subjects who saw the linear versions would "fill up the whole screen." Finally, there was a rather strong desire by those seeing the conceptual versions to "add people"; indeed, one very bright youngster in a sixth-grade group said, "It would be better...to have the squares, circles, and diamonds be anthropomorphic and walk around the stage like humans."

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# VIII. INTERPRETATION

This section presents a summary of the study, states specific conclusions that may be drawn from the data, discusses the exploratory implications of these data and conclusions, and makes recommendations for further study.

## A. SUMMARY

### Objectives

This was an exploratory study that used controlled experimentation to examine the non-linear relationship between humans and their informational environments. The first major problem of the study was to measure the relative effects upon learning of (1) visual images presented non-linearly, that is, cumulatively or simultaneously; and (2) visual images presented linearly, that is, sequentially. Examination of this central variable was also extended to include fundamental variations in the treatment of content: to measure the effects upon learning of subject matter presented at several levels of abstraction. These explorations were conducted at two grade levels, six and eight, and included consideration of related variables such as sex, Language IQ, ability in Arithmetic Reasoning, and environmental conditions. Effects were measured on three levels of learning; knowledge, comprehension, and application.

### Materials

Stimulus films. The filmographic mode of presentation was used in each of six films shown to the experimental groups on each grade level. Three of these films were produced in a non-linear format: the images were displayed cumulatively or simultaneously, scene by scene. The other three films were produced in a linear format: the same images were displayed sequentially, one after another. The content of the filmographs was treated in varying degrees of abstraction; that is, two of the films, one non-linear and one linear, contained only factual material: photographs and verbal description of the processes and events presented. Another pair emphasized the conceptual aspects of the content, using non-representational drawings and verbal explanation to convey an abstracted version of the same processes and events. A third pair of films mixed the emphases in the contents of these two extremes.

Where appropriate, the sound track shifted emphasis from description to explanation, and in each case the shift was supported by a comparable shift in imagery.

The flow-charting process, used in computer programing, and real-world counterparts of sequences in this process were selected as subject matter for the films. Scripts were prepared according to the requirements of the experimental design and were controlled for length and readability. Art work was developed in parallel with script preparation and in accordance with experimental controls. One of the six films was completed and pretested in conjunction with the development of the measuring instrument.

Measuring instrument. A test was designed that would measure the effects of the stimulus films on three levels of learning: knowledge, comprehension, and application. Test items were categorized and evaluated by seven specialists. The resulting test was used in two tryouts to permit refinement and to assess reliability before use in the experiment. Evaluation of the final test included correlation analysis of immediate and delayed responses and factor analysis of immediate responses.

## Procedures

Schools with experimental subjects were selected for their representativeness, their facilities, their availability, and their size. Subjects were assigned at random to each of twelve film groups and two control groups. Facilities, environment, film presentation, and testing procedures were all controlled for consistency. Tests were scored under strict instructions, and resulting data were carefully checked for error prior to and during preparation for computer analysis. Data were collected on the abilities, achievements, and attitudes of the subjects. Correlation, variance, covariance, and factor analyses were conducted.

## Findings

Differences among the mean scores of the film groups for each grade were found to be relatively small, though in some instances statistically significant. Although the sub-tests were found to be only moderately correlated with each other, they were found to be highly correlated with total scores. Total scores of parts two through four of the test were therefore used in the final analysis.

Immediate test. Analysis of responses to the test administered immediately after the film showed that:

(1) Sixth grade: (a) differences among the content variables were significant (.01); (b) there was a significant (.05) interaction among the content and

format variables. The null hypothesis was accepted in all other phases of this analysis.

(2) Eighth grade: there were no significant differences among the variables.

Delayed test. Analysis of responses to the test administered four weeks later showed that:

(1) Sixth grade: differences among the content variables were significant (.01). When immediate test scores were added as a covariate, the level of significance was reduced (.01 to .05). The null hypothesis was accepted in all other phases of this analysis.

(2) Eighth grade: difference in response by the two sexes was significant (.01). This difference remained when immediate test scores were added as a covariate, and, in addition, a significant difference (.05) appeared in the interaction between the sex and format variables. The null hypothesis was accepted in all other phases of this analysis.

(3) Control groups: there was a significant difference (.01) between two groups that received both the immediate and the delayed tests and two groups that received only the delayed test. The null hypothesis was accepted in the other phases of this analysis.

Other analyses. A factor analysis was undertaken to help clarify the patterned relationships between the test items and the subject matter of the stimulus films as they were experienced by the students of both grades. In addition, subjective items were included in the test, and interviews were conducted to gain qualitative insight into this experience.

(1) Factor analysis of responses: six principal factors were identified and were respectively interpreted to indicate that the test measured (a) ability to match cue phrases with symbols, (b) understanding of the concept of flow as represented by arrows, (c) ability to recognize verbal statements as sequences of happenings, (d) ability to relate symbols within a flow chart to verbal descriptions of events, (e) comprehension of the concept of order, and (f) ability to position appropriate symbols within a sequence of happenings.

(2) Qualitative evaluations: students felt that (a) the films were of acceptable length, rate of development,

and clarity; (b) the early parts of the films were "better" than later parts; (c) the films were repetitious; and (d) the younger students felt that they had learned more. Very few students had seen such films before.

## B. CONCLUSIONS

Results for the sixth grade groups support the conclusions that:

(1) If this kind of subject matter is to receive factual treatment, then the linear format is best for both immediate learning and for retention.

(2) If the subject matter is to receive a mixture of factual and conceptual treatment, then the non-linear format is best for immediate learning.

(3) Students at this level do not learn or retain this kind of subject matter well when it is treated conceptually in either linear or non-linear format.

Results for the eighth grade groups support the conclusions that:

(1) Students at this level learn this subject matter equally well in either format and with any of the three different ways of treating content.

(2) Males retain this subject matter best in the linear format.

(3) Females retain this subject matter best in the non-linear format.

(4) The film combined with the immediate test improves retention over use of the film alone.

Results for both grade levels support the conclusions that:

(1) Mode of presentation has less effect on learning as the student grows older.

(2) Ability to comprehend and to apply subject matter of this type taught in these ways improves with age.

## C. DISCUSSION

This study was conducted to explore a single concept, nonlinearity, and to relate the results of this exploration to the design and utilization of composite messages. Discussion of these relationships will be presented in two stages: the first will address the procedural aspects of the study, in particular the approach taken to measurement, and the second will address insights gained into the design of the messages that were used in the study. Emphasis in the discussion has been placed upon exploratory analysis of trends revealed by the study and of methodological insights believed to be of importance to this and future studies.

### Administration, Measurement, and Analysis

As has been reported at some length, considerable care was taken in the conduct of this experiment. The size of the sample, the random assignment of subjects to experimental groups, the exercise of controls, the development and refinement of the test, and the preparation and analysis of the data; all were believed to have been implemented effectively. It was hoped that precision in these matters would permit confident isolation of the central elements in the study, the messages. This was believed to have been accomplished.

Although the test as developed and administered did its task well, experience and the literature have suggested alternative approaches that would undoubtedly have yielded additional insights into the relationships between the subjects and the films. For example, the use of learning as the sole dependent variable may have been too restrictive, even though central. In this regard, Ericksen (1954) suggested in his study of stimulus differences that "the effects... depend in some measure upon the response studied and the nature of the task." A truism, certainly, but a point well taken in this context. This problem was anticipated in the present study, as evidenced by the multi-level measure that was used; however, these levels were still levels of learning. Also, the three levels that were used may have been too few or the wrong three for measuring the broad effects of these stimuli. Additional insights might have been gained if the higher orders of learning suggested by Bloom (1956) had been used, or if Reed's (1950) distinction between the effects of simultaneous verbal presentation upon the search for meaning vs. serial presentation upon rote learning could have been incorporated into a more comprehensive mode of testing. Other dimensions will be identified in the discussion and recommendations to follow:

A second factor of importance to the measures used in this study had to do with the relationship between the stimulus and the test. Hartman (1961) in his very comprehensive review of the literature of single- and multiple-channel communication, pointed out that verbal testing of pictorially presented information may distort the results. To be sure, the test used in the present study provided many pictorial cues drawn from the stimulus films and used the content of the sound track in the construction of the items; however, the test also contained verbal material that mediated the visual-verbal and stimulus-subject relationships, and this may in turn have affected the results. Also, in this regard, Hartman concluded in his paper that "the learning of information presented in several channels is more likely to be demonstrated if it is tested on several channels. Since black and white print was used as the channel in this study to test material that was presented pictorially and on film in color, and since the primary responses elicited were in writing, it may be possible that somewhat different results might have been achieved had several modes of measurement been used.

Finally, a third factor was suggested by the qualitative approach to assessing stimulus effects that was used by Malandin (1962) in his studies. He interviewed each member of his sample individually, using grouped and separate frames from his film strips as cues to elicit learned responses. In the present study this kind of approach was not feasible for the total population; however, the interviewing of film groups that was done suggested the potential value of more detailed discussions with selected members of the groups. Also, more may have been discovered if the group interviews had been less general (that is, more specific to particular sequences and time periods in each film), the results then to be compared from film to film. The objective in this approach would have been to achieve greater specificity and depth in assessing responses to selected aspects of the stimulus films.

## Message Design

The pedagogical utility of messages designed for repeated use in education justifies the care and expense required to devise needed design techniques and to test and apply them. Several such techniques were devised and tested in this study. It is hoped that the following dissection of the results will suggest means for increased precision in shaping messages.

Verbal elements. The results of this study imply that, contrary to recent revolutionary interests in multiple imagery and contrary to the insights reported by Malandin and others, as reviewed in Section II, there is really little cause for excitement. However, examination of Table XI shows that the difference between the non-linear and linear formats for the sixth-grade groups barely missed significance at the .05 level, and that this difference held up well in the delayed test (Table XVII). Also, the mean scores for these groups favored the non-linear format in both the immediate and delayed tests (Tables XIII and XVIII). These differences become important, even though not significant statistically, when it is remembered that they were produced by variation in the visual component only. The scripts for each content pair of films (F:FC:C) were identical. Application of this control may thus have weakened the total impact of the films, but it served its purpose by isolating the effects of variation in visual format.

Similar control of the verbal component along the content dimension of the study may also have compromised the impact of the films. Here emphasis was shifted in a manner closely approximating the visual elements of the films; that is, from the specific to the general, from straightforward description of the visual sequence to interpretive explanation of the concepts and principles involved, from the factual to the conceptual. However, in achieving this fit of elements of the message one to the other, control was exercised for length, readability of language, comparability of scenes, and so on. Increased clarity and precision of impact may have been achieved had some of these controls not been imposed, that is, if the language structure had been as abstract and as non-linear as the visuals--fewer words precisely placed...on cue...varying in pace... as the rate of conceptual development required.... The shifts in the factual-conceptual versions, where the abstract and the concrete were mixed, might then have fitted even more closely the prescription offered by Miller (1957):

> When trying to build up a general concept, it might be desirable to fade from one concrete example to the abstract representation, and then to a different concrete example, continuing the process until the main dimensions of variability were covered.

Precisely this was done in the two factual-conceptual films; however, because the possible variations in language were limited, it is postulated that a levelling effect was designed into the films by the audio narration, and that their impact was reduced.

*Visual elements.* Each of the two types of formats that were compared in this study had advantages and disadvantages that appeared not to be equivalent in their effects. Malandin (undated a) found in his studies that the younger students could not relate one image to another if they were isolated in time, that is, present sequentially. Reed (1950) found that simultaneous presentation permitted subjects to search for meaning among the stimuli, whereas serial presentation produced concentration "upon learning the names of the cards rather than working out their meaning." In addition to this consequence of the format used to deliver stimuli, their relevance to each other and to the desired response was also crucial. As Miller (1957) put it:

> When cues from different modalities (or different cues within the same modality) are used simultaneously, they may either facilitate or interfere with each other. When the cues

> elicit the same responses simultaneously, or different responses in the proper succession, they should summate to yield increased effectiveness. When the cues elicit incompatible responses, they should produce conflict and interference.

Considerable care was taken in this study to achieve summation; however, success in this effort was not measured. Some indications did appear during the interviews to suggest that interference was operating in the non-linear films. For example, several complaints were made that there were too many pictures, and that difficulty was experienced in relating the flow charts to the pictures. Isolation in the linear films would tend to reduce this interference and thus favor this format (Postman and Phillips, 1954; Johnson, 1955).

In this regard also, there may well have been problems in accommodating the scanning needs of those who saw the many images of the non-linear versions. As Ely, Bowen, and Orlansky (1957) put it, "The act of discrimination takes time: the more difficult the discrimination, the longer the time." Israeli (1950)also concluded, "The more intricate the stimulus pattern, the longer the time required for perception of that pattern.... Longer time is necessary for integrative operations. This reflects effort and work in combining parts."[1] Also, Reed (1950) pointed out that a certain minimum length for a given sequence was indicated:

> In simultaneous presentation [or words], a certain minimum length of series is necessary to form correct concepts with an economical amount of effort. If the length of the series is below this minimum, the amount of work is greatly increased.

Also, Miller (1957) stressed the importance of the "size of the functional units." Increased effort would undoubtedly require more time for satisfactory results; thus time and task are closely linked (Eysenk, 1942). Although specific sequences in the films were not evaluated one by one for their order of difficulty and the time required for a sample to reach a criterion measure, judgments were made on their rate of development and the relative complexity of the images used; and controls were applied to the development of the script. The fact that the sixth-grade students tended to learn best from the non-linear films (Table VII), suggests that these estimates were successful in managing the problem of excessive complexity and in meeting the adaptation needs of the subjects. However, since these effects were not measured sequence-by-sequence, the possibility remains that in some sequences, the progressive development of the subject matter as presented may have been inhibited by inadequate precision in control of relationships between rate and complexity.

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[1] Glanzer (1958) discussed the relationship between presentation rate and adaptation level, as it moves from boredom to confusion.

Along the content dimension of the study, results confirmed Carpenter's (1953) "sign similarity hypothesis":

> That films whose signals, signs, and symbols have high degrees of similarity ('iconicity') to the objects and situations which they represent will be more effective for most instructional purposes than films whose signals, signs, and symbols have low degrees of 'iconicity.'

Johnson (1955) having reviewed the literature of concept formation, as related to responses to complex patterns, concluded similarly that "conceptualization is therefore easier the more it resembles the perception of concrete objects." The low scores on the conceptual versions (Table VII) support this contention. However, Miller (1957) suggests an alternative closer to the approach used in the present study:

> Often the actual object or piece of equipment may be too specific. We are interested in teaching a response which will generalize to a whole class of objects or situations. This generalization can be facilitated by using techniques, such as caricature and diagrammatic simplication, to emphasize the cues that are common to all of the members of the class, and to minimize or omit the cues that differ.

Experience in the present study indicates that facilitation of this order of generality is both desirable and feasible but requires more than straightforward attention to cues, although cue control is certainly fundamental.

Those students who saw the conceptual versions said in their group interviews that they felt the films could be improved if there were "people in them." This recommendation suggested a need on their part for representation more familiar to them than the symbolic drawings that were used in the films. Both Vernon (1955) and Miller (1957) emphasized the need, in dealing with novel graphic symbols, for the observer to have adequate time to learn their meaning. Iakimanskaia (1959) is reported to have stressed that reading of geometrical forms requires an interplay of "sensory and conceptual analysis, synthesis, and abstraction." And both he and Chaplin (1960) emphasized the dominant role of the conceptual processes over "mere perception."

In the present study, attempts were made to accommodate most of these requirements. However, it is believed that even greater precision and more detailed (i.e., sequence-by-sequence) pretesting would be required to realize the potential impact of this abstract mode of address. Each of the films used in the study included several early scenes to familiarize the subjects with the style of treatment; the symbols used in the conceptual and factual-conceptual films were kept very simple and used common symbolic forms such as circles, arrows, exclamation points, numbers, and so on; where many symbols appeared in pattern, the rate of introduction was carefully controlled, and several means were used when appropriate to cue for relevance; finally, strong verbal cues were given in the sound track to identify the concept being portrayed graphically (see final scripts in Appendix B).

However, the results show that in spite of these efforts, learning from the conceptual films was relatively difficult for both grades (Tables XIII and XX). The groups may not have been measured on a level of abstraction high enough to identify the salient effects of this mode of address; that is, as Iskimanskaia (1959) suggested, analysis and synthesis was involved, while the highest order of learning measured in this study was application. Bloom (1956) upon whose taxonomy the test instrument was based, ranked analysis and synthesis higher than application and among the three highest levels of learning.

Verbal and visual combined. The composite message has its own characteristic requirements for effectiveness. These requirements pose difficulties of an intricacy second only to the problems of relating the message design to its individual user. Hartman (1961) has provided an extensive review of these problems and of the relevant research to date. From his examination of studies of interchannel interference he concluded:

> that interference occurs when unrelated information is simultaneously presented and attention cannot be successfully alternated, and that it reduced the learning in both channels; that increasing the difficulty of the presented information results in increasing losses through interference; that when the information presented in the channels is of unequal difficulty, the less difficult information suffers the greater loss.... Interference may also be generated by adverse cognitive relationships in information.

One solution offered to these problems was to keep the level of difficulty "low enough to permit attention to alternate between channels " (Hartman, 1961). However, if the desired result is elevation of the observer's ability in a particular subject or task to a higher level, and at a reasonably efficient rate, then this solution is unduly restrictive.

In the present study, the images were selected and scripted for shooting on a frame-by-frame basis. However, limitations of available photographic imagery, difficulties of making equivalent graphic interpretation of processes, achievement of consistency in rates of change from film to film and other controls applied to keep the films comparable experimentally, tended to restrict the developmental freedom possible were only a single film being developed. And these controls were exercised only judgmentally. Means available for assessing the consequences of asynchronous variations in difficulty were gross at best, particularly for the graphic component. It was quite likely, therefore that interchannel interference of the types described by Hartman were operating in the stimulus films. If this were true, then it would have been to the particular disadvantage of the non-linear versions because of their multiplied image relationships--lag between presented verbal terms and available cumulated imagery (Zuckerman, 1949)--and also to the disadvantage of the conceptual versions because of apparent difficulties in relating verbal terms to novel graphic symbols.

A second major characteristic of the composite verbal-visual message is even more basic and poses problems well beyond the limits of the present study. However, it is relevant in this context and of adequate importance that it should be addressed even if only briefly (Langer, 1942):

> Visual forms--lines, colors, proportions, etc.--are just as capable of *articulation*, i.e., of complex combination, as words. But the laws that govern this sort of articulation are altogether different from the laws of syntax that govern language. The most radical difference is that *visual forms are not discursive*. They do not present their constituents successively, but simultaneously, so that relations determining a visual structure are grasped in one act of vision. Their complexity, consequently, is not limited, as the complexity of discourse is limited, by what the mind can retain from the beginning of an apperceptive act to the end of it.
>
> . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
>
> The meanings given through language are successively understood, and gathered into a whole by the process called discourse; the meanings of all other symbolic elements that compose a larger, articulate symbol are understood through the meaning of the whole, through their relations within the total structure. Their very functioning as symbols depends on the fact that they are involved in a simultaneous, integral presentation. This kind of semantic may be called 'presentational symbolism,' to characterize its essential

> distinction from discursive symbolism, or 'language' proper.[2]

This basic difference between the ways in which words and images codify and present reality raises interesting points concerning the differential effects that might be expected from the types of messages used in this experiment. Not only were all of the scripts essentially sequential in their delivery, but each of the sets of multiple images demanded clarity in relational content to achieve optimal impact. The cumulative pattern of presentation in the non-linear films plus the highly variable and at times incidental relevance of some images may have compromised the impact of an otherwise simultaneous presentation. Interestingly, this latter insight is debatable--for example, the addition of a new image might be seen to have created a new and simultaneously presented set of relationships, or it might be seen as having been only sequentially introduced into a static field--and without adequately detailed data these issues must remain debatable. Also, Langer assumes instantaneous perception of the visual image; whereas Buswell (1935) has demonstrated that although the perceptual process is very rapid, it is still sequential. However, the visual meaning rate is sufficiently rapid not to invalidate Langer's basic point, and her distinctions lend considerable excitement to further inquiry.

## D. RECOMMENDATIONS

Inasmuch as this was an exploratory study, it was believed that every effort should be made to penetrate its implicit objective, the clarification of requirements for effective design of informational messages. Hence, a rather harsh and objective analysis and evaluation was undertaken above in an attempt to move beyond the immediate statistics and procedural confines of the reported study. The implications of this discussion have been formalized below into a series of recommendations ranging from explicit follow-up studies to flights of fancy. For convenience and interest, these formulations begin with the most general, move freely to particulars, and conclude with speculation.

### The Design Process

Possibly the most fruitful general class of studies that could be undertaken in the area of message design would be an examination of the design process itself: the assumptions commonly made, their patterns and relationships to intent and process; classes of objectives; expectations for control as related to concepts of optimum design, precision, and predictability; patterns of decisions as a function of time and other salient variables (current planning and control procedures such as the Navy's "Planning, Evaluation and Reporting Technique" [PERT] (Malcolm, 1959) could be used as the initial model here); classes of operational criteria used for selecting and mixing media; the "architecture" of the time-space message structure as implicit in a variety of existing message designs (i.e., newspapers, drama, short story, speeches, technical reports, sales "pitches," advertising commercials in the several media, essays, briefings, military commands, and so on), always seeking the essential structure of the messages; and finally, the design process itself in its totality and in the context of the communication event system. There are many well-known models of this event system as pointed out in Section II above, but none of the message-design subsystem, except as a very specific component of large-scale, message-producing organizations. There the models exist as part of the production or management control systems rather than as means for improving the message-design process itself. Perhaps generic in this regard, problem-solving models would provide an excellent initial frame of reference for early work in this area (Johnson, 1961).

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[2] Essentially this same distinction was also made by Ruesch and Kees (1956) when they noted the digital character of language and the analogical character of nonverbal communication.

## Design Structure

If precision of effect is desired, then controls must be exercised in the design of the message to ensure flexibility of access that is adequate, within establishable tolerances, to accommodate the highly variable characteristics of the individual and grouped observer. In order to do this with a fixed message such as film, the designer must seek to control key elements in his design. This study found several such requirements for control to be of particular importance in this context.

Attention. Studies need to be undertaken that will codify the mechanisms available to the designer for managing the attention of the users of his informational messages. Currently, the most advanced techniques are being used to design the fiercely competitive messages used in advertising or the severely cryptic messages used in military systems. These tend to be useful primarily for very brief informational messages intended to influence decision and choice. Their relevance to the design of tutorial messages must be assessed and possibly tested. Also, relevant basic studies of attention need to be reviewed, integrated, and assessed as they relate to message design and structure.

As was suggested earlier, analytical techniques need to be developed for optimizing shifts of attention between messages delivered through several channels at once. It is known that shifts in attention do occur; the problem thus becomes one of determining how to make the most of this trait of the human observer (Hartman, 1961; Stroud, 1932; Kohler and Adams, 1958; Berlyne, 1958). It is further suggested that multi-measures be used to assess variations here. In particular, two seem very promising. The first would use a real-time computer that would be central to both the criterion task and to one or more observers. The observers would note their observational tallies on multi-buttoned keyboards coded to suit the expected responses. Both responses and tallies would then be processed appropriately by the computer and recorded by time of occurrence for later interpretation. Also, estimates and interviews concerning the passage of time could be used as a means for relating psychological time to learning. It is postulated here that high attention levels would be accompanied by loss of awareness of the passage of time and hence in fact would result in enormously wide ranges in attention span. It would be useful to know what kinds of message designs yield this effect.

Interference and complexity. As was noted earlier, interference was thought to have played an undetermined role in the present study. Additional, fruitful studies could be undertaken to develop an anatomy of image interaction. One of the early problems in this area would be to develop a measure or measures of the concomitant effects of several varients of the multi-imaged format upon learning. Hartman (1961) also calls for study of the "conditions governing...facilitation relationships...such as the success of a verbal label in improving the learning of an ambiguous drawing.[3] Under what conditions do the relationships among images and words interfere and what facilitate? Is there a predictable visual-verbal ratio perhaps related to the conceptual system of a given message (Cooney, 1961)? What kinds of interactions (both in space and through time) increase complexity? What factors affect the limits of tolerance for complexity? What are the relationships between rate and difficulty in the development of a message during presentation (Newman, 1962)?

Development. Arnheim (1960), in a discussion of choreography, reflects that "appearance is linked to definite phases of the total development, and different meaning goes with different locations in the perceptual sequence." Developmental structure is not a new idea by any means, but reconsideration of it would be timely in the light of modern means for delivering messages and in the light of recent concepts concerning mechanisms for control (feedback) as they relate to the design and evaluation of messages. Recent emphasis by Bruner (1960) upon the importance of structure is suggestive here:

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[3] Also in this regard see Max Wertheimer (1950).

> Perhaps the most basic thing that can be said about human memory, after a century of intensive research, is that unless detail is placed into a structural pattern, it is rapidly forgotten.... The teaching and learning of structure, rather than simply the mastery of facts and techniques, is at the center of the classic problem of transfer.

Precisely what is the role of structure in relating message components to the needs of the learner, and what are the terms of that role in the new media? To be somewhat more specific, examination of text books or technical reports and films show clearly that different assumptions are being made about the required length of given stimulus patterns. To be sure, the economics of the two media strongly influence decisions here. However, if one were not basing his design structure upon crude assumptions about one's audience, or pocketbook, or habit, but instead were to address the precise task of interpretation, without doubt the length of subsequent messages would become markedly shorter, the content more precise (Israel, 1950). Might it be relevant, perhaps, to consider structuring a message in terms of psychological time rather than in terms of units of subject matter? This orientation would require consideration of what it is that influences time perception and would immediately establish different criteria for making decisions about a given message.

The process of shifting one's frame of reference, one's point of view, one's set, is also of crucial relevance to message design (Johnson, 1955; Hebb, 1949; Berlyne, 1951). In the former context, psychological time, the placement of relevant cues might well be determined primarily by emotional rather than logical timeliness. In both the psychological and the physical time scales, development of the learning experience might be optimally controlled by precise placement of cues designed to shift the emotional and the logical frames of reference of the learner (Postman and Bruner, 1949). The non-linear response patterns of the observer would make precision of predictive placement for any given individual doubtful; however, as was noted in the review of literature above, profile techniques offer at least a preliminary means for assessing optimum placement. Other measures might be rates of error, tolerance of or speed of delivery, accommodation of varying content, and patterns evident in observed perceptual responses. It might be that interference intentionally introduced preceding crucial cues would develop readiness to recognize the crucial cue or set of cues. An appropriately designed multiple-image format might be used to introduce the interference by presenting apparently unrelated images that would be resolved by an isolated cue image; or, the reverse, a series of rapidly presented images in isolation, whose relationship would be reinforced by simultaneous summation.

The rate of both change and delivery may thus also be seen as an important dimension in the study of message design. Probably the limiting factor for either verbal or visual presentation would be the rate of scan for each channel. Study is needed here to determine more precisely the patterns of differential scanning rates for composite messages, and thus to clarify the requirements for fitting both images and words to the variable characteristics of groups and individuals. Investigation may well show that effective use of composite messages will permit drastically increased input and processing rates and will, when appropriately structured and paced, more clearly define the effective role of graphic communication.

Flexibility. Most of the preceding recommendations have been made under the assumption that messages must first be designed, then produced, then delivered; in short, that they are a fixed unit or sequence of deliverable content embedded in an appropriate vehicle for delivery. The required "fit" to the acknowledged non-linear variability of the human processor must be specified in detail, thus requiring elaborate and precise measurement or at least estimate of the elements of variability in advance. But why must the message be fixed? Why must the message be designed for the observer? What might be required to permit him to design his messages for himself, in real time, as his learning or speculative needs require? The specification here is not for a message with fixed logic, but for an adaptive, flexible, accessible source of raw or semi-forumlated information to be delivered precisely as required (Fearing, 1953).

Within the traditional technology, the criterion of flexibility would rate the textbook higher than the film as a medium--recognizing, of course, the different codification and scanning characteristics of the two media. The film might be made more flexible in use if combined either with novel projection facilities or with related media. For example, a short loop of film might be used as the carrier of the unit message; then, single frames from the film might be subsequently projected for discussion using a random-access projector to permit immediate manipulation of the sequence of frames as desired by the teacher. The short loop might then be shown again in order to restructure the now disassembled logic. Several quick passes through these images might well convey and confirm even the most difficult materials to the most restricted learners. But this would still be group instruction, and the real need is to accommodate individual variability, rapidly.

Computer-controlled access and delivery of information offers promising potential for providing radically improved fit of the message to the changing needs of the individual (Finn, 1960;

Coulson and Silberman, 1961; Busnell and Cogswell, 1961). These methods thrust into being both new possibilities and new demands. The rationale for message design developed above would shift emphasis from pre-assessment of the inherent non-linearity of the human processor to current and continuing assessment; rate and precision of delivery would meet new standards; cue control would become a process of real-time sensing by the machine; interference and attention levels might also be assessed, and complexity levels might eventually be paced as proposed by Newman (1962). The limiting factors in this approach seem to be machine capacity, codification and retrieval of the massively complex classes of information relevant here, and cost. Once these problems have been resolved, and there is clear promise of this, there will quite likely follow a drastic revision in traditional thinking about strategies for learning (Hoagland, 1962; Simmons, 1962; Danko, 1962; Christianson, 1963). Flexibility of this order in message design may introduce the application of search and problem-solving models as central in the design of curricula and their supporting information systems (Johnson, 1955; Janson, 1958; Fearing, 1962; Merrifield, 1962; Polya, 1957). Retention of traditional subject matter may well remain the substance of the educational process, but the basic means as well as the goals will be enhancement of the individual's creative interaction with his informational environment.

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# APPENDICES

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# APPENDIX A

## "MAKING THINGS HAPPEN"

### Factual Version

1. Many times a day...every day...we make things happen that are important to each of us.

2. These may be simple things like deciding what food to eat... what clothes to wear...or what game to play.

3. Or these things may be complicated and difficult like those scientists and engineers make happen when they launch a man into space.

4. When we make things happen, we make CHOICES and DECIDE what to do. Then we make sure that everything happens just the way we want it to, so that nothing goes wrong. And finally we need to make sure that the right things are COMPLETED at the right time.

5. This film is about making things happen. It will show you HOW things happen. It will even give you some tools to use to make these things happen the right way.

6. For instance, we know that when we have a meal, we must first decide what food to eat. Then the food must be prepared. Finally, we eat the food, and the meal is completed. So we can see that even in such a simple happening as having a meal, each step follows the other in a very particular way.

7. This arrangement of steps, one after another...is called a sequence of happenings.

8. Each step has its correct place in the SEQUENCE of happenings. Just as with eating, so, too, many other happenings can be made to take place...just so...in their own special way.

9. We also know that, when we make things happen, three different kinds of things take place.

10. First, we DECIDE what to do. This may be a decision whether to have oatmeal or dry cereal to eat.

11. Next, we DO something about the decision. We may prepare the cereal and then put it on the table.

12. Finally, we COMPLETE this action. We eat the cereal. What was started earlier is now completed.

13. So when we eat a meal, or get dressed, or play a game: We DECIDE to do something...we DO it...and we COMPLETE it.

14. When scientists and engineers make more complicated things happen in sequence, they use a special kind of drawing called a FLOW CHART.

15. The flow chart is a kind of map for making things happen.

16. It uses special symbols like diamonds, squares, and circles to describe what kinds of things are happening.

17. This symbol means that a DECISION is made. It could be a decision to buy food...or even to launch a rocket into space.

18. This symbol means that something is BEING DONE. It could mean that we are preparing food or that we are launching a space rocket.

19. This symbol means that something is COMPLETED...such as the end of a meal or the end of a rocket trip.

20. We use these three symbols, with connecting arrows, as a FLOW CHART. They show us each of the different parts of anything we want to make happen...the DECIDING...the DOING...and the COMPLETING.

21. When put together, these symbols and arrows show how each part of the happening fits in with every other part.

22. For example...a car ride.

23. We begin by DECIDING to go...

24. Or not to go.

25. And if we go...

26. Then we must DECIDE when we are ready to return.

27. Or to wait awhile...

28. And then return.

29. Arriving home we stop...the ride is COMPLETED.

30. The flow chart shows us what is DECIDED, what is DONE, and that the car ride is COMPLETED.

31. The FLOW CHART is also used by scientists and engineers to show what happens when a rocket launches a man into space.

32. A DECISION is made whether or not to launch the rocket.

33. If "no," the launching is stopped.

34. If "yes," a number of different things happen.

35. The astronaut puts on his space suit...and,

36. While the engine is fueled,

37. Different parts of the rocket are checked,

38. And radar tracking stations report readiness.

39. Then the question is asked, "Is everything ready?"

40. If "no," the launching must wait until the problem causing the delay is corrected and everything is ready for blast off.

41. When "yes," the rocket blasts off. The launching part of the astronaut's trip into space is COMPLETED.

42. While the space capsule is in space, computers determine the orbit and tell exactly where and when it must leave orbit to return safely to earth.

43. The computer is asked, "Is it time to leave orbit?"

44. If "no," there must be another delay until it is time.

45. If "yes," the return rockets are fired.

46. As the space capsule approaches the earth, many things happen.

47. The FLOW CHART shows how each of these things must happen.

48. First, slow down retro rockets are fired...then recovery parachutes are released...and when the capsule has dropped slowly into the ocean, recovery teams fish it out of the water.

49. The astronaut is safe.

50. This COMPLETES the recovery part of the space trip.

51. The FLOW CHART has shown us how to make the RIGHT thing happen at the RIGHT TIME.

52. The FLOW CHART can also be used by other people to make things happen the SAME WAY over and over again. It is like a map of the many things that must happen.

53. It uses a special language of diamonds, squares, circles, and arrows which tell what kind of action must take place: a DECISION...a DOING of something...and a STOPPING.

54. So we have learned that almost anything we make happen--whether it be the simple act of eating food, taking a ride, or even rocketing a man into space--happens in a step-by-step way... that it contains three different kinds of actions...and that we can make it happen the right way each time by mapping out each step on a flow chart.

THE END

## "MAKING THINGS HAPPEN"

### Factual/Conceptual Version

1. Many times a day...every day...we make things happen that are important to each of us.

2. These may be simple things like deciding what food to eat... what clothes to wear...or what game to play.

3. Or these things may be complicated and difficult like those scientists and engineers make happen when they launch a man into space.

4. When we make things happen, we make CHOICES and DECIDE what to do. Then we make sure that everything happens just the way we want it to, so that nothing goes wrong. And finally we need to make sure that the right things are COMPLETED at the right time.

5. This film is about making things happen. It will show you HOW things happen. It will even give you some tools to use to make things happen the right way.

6. To begin with, we know that most things happen in a step-by-step ORDER. One step follows the other...in ORDER. For instance, when we have a meal, we must first decide what food to eat. Then we have to prepare it. Finally, we eat the food. So you can see that even having a meal happens in a special step-by-step ORDER.

7. This orderly arrangement of steps is called a SEQUENCE of happenings.

8. So we learn that things can be made to happen in a certain ORDER. We can make them happen that way by giving each step its correct place in the SEQUENCE of happenings.

9. We also know that when we make things happen, three different kinds of things take place.

10. First, we DECIDE what to do. We make a choice...a DECISION. For instance, we may DECIDE what we want to eat.

11. Next, we actually DO something about it. We take action. We prepare the food.

12. Finally, we COMPLETE the action. We eat the food. This particular step is FINISHED...the sequence is COMPLETE.

13. These are the three parts of any sequence of happenings: DECIDING what to do, DOING it, and COMPLETING it.

14. Because these happenings are found in any sequence, we can make we can make a map or chart of even the most complicated sequence of happenings.

15. Scientists and engineers call this map a FLOW CHART...

16. In the FLOW CHART they use diamonds, squares, and circles as symbols that help to plan an entire sequence of happenings and all of its steps.

17. This symbol means that a DECISION is being made...the first step in a sequence. What shall we eat? When will the rocket be launched into space?

18. This symbol means that something is BEING DONE. Action is tak-taking place...preparing the food to eat...actually launching the space rocket.

19. This symbol means that something has been COMPLETED...the end of a meal or rocket trip. All action can now stop.

20. These three symbols, with connecting arrows, are used as a FLOW CHART to plan the beginning or DECIDING...the middle or DOING... and the end or COMPLETING of anything we want to MAKE HAPPEN.

21. By combining these symbols and arrows we can PLAN happenings that have many steps and still keep all the steps in ORDER... in SEQUENCE.

22. For example...a car ride.

23. We begin by DECIDING to go...

24. Or not to go.

25. And if we go...

26. Then we must DECIDE when we are ready to return.

27. Or to wait awhile...

28. And then return.

29. Arriving home we stop...the ride is COMPLETED.

30. The FLOW CHART shows what was DECIDED, what was DONE, and that the sequence was COMPLETED.

31. The FLOW CHART is also used by scientists and engineers to PLAN the SEQUENCE of steps for more complicated problems...launching a man into space, for instance.

32. A DECISION...the first step in the sequence...to launch...or not.

33. If "no," they stop the launching.

34. If "yes," many things happen all at the same time.

35. That's why a flow chart is used...

36. To plan these many things...happening TOGETHER...

37. SIMULTANEOUSLY.

38. Because it can show the ORDER...and TIMING...and SEQUENCE.

39. A DECISION is made..."Is everything ready?"

40. If "no," they wait...asking the question over and over...until everything is ready.

41. If "yes," the rocket blasts off. ACTION takes place. The launching sequence is COMPLETE...ended.

42. Now...the decision to return to earth..."Is it time to leave orbit?

43. Scientists use computers to check every detail to be sure everything is exactly as planned earlier on the Flow Chart.

44. If "no," they wait, checking over and over...until the right time.

45. If "yes," many things happen very rapidly.

46. Return rockets are fired...

47. Slow down parachutes are released...

48. Recovery teams rescue the men...

49. That's why the Flow Chart plan is needed...to keep track of each thing to be done...

50. So no mistakes will be made...So things will happen in the RIGHT ORDER...So the recovery of the astronaut can be completed safely.

51. We use it to PLAN things and to understand how to make things happen.

52. The flow chart can also be used by other people to make things happen the SAME WAY over and over again. Because it is like a map of what will be made to happen.

53. It uses a special language of diamonds, squares, circles, and arrows which represent what kind of action will take place... a decision...a doing of something...and a stopping.

54. So we have learned that we can make most things happen in an orderly step-by-step way...so that each happening contains three different kinds of actions...and that we can make things happen the same way each time by PLANNING each step in sequence on a FLOW CHART.

THE END

## "MAKING THINGS HAPPEN"

### Conceptual Version

1. Many times a day...every day...we make things happen that are important to each of us.

2. These may be simple things like deciding what food to eat... what clothes to wear...or what game to play.

3. Or these things may be complicated and difficult like those scientists and engineers make happen when they launch a man into space.

4. When we make things happen, we make CHOICES and DECIDE what to do. Then we make sure that everything happens just the way we want it to, so that nothing goes wrong. And finally we need to make sure that the right things are COMPLETED at the right time.

5. This film is about making things happen. It will show you HOW things happen. It will even give you some tools to use to make things happen the right way.

6. Many things can be made to happen so that one step follows another in ORDER. When this is done, we can easily decide which step must happen first. Then we can choose the next step, and the next, so that each will play its right part in the happening. Then, by checking each step as it happens, we will know when all of the steps have been completed.

7. We call this arrangement of happenings a SEQUENCE because each step follows the other in ORDER.

8. We can arrange each step with care so that we can be sure we have chosen the BEST way for that sequence to happen--each step happening the RIGHT way at the RIGHT time.

9. We also know that when we make things happen, three different kinds of things take place.

10. First we DECIDE what to do. This means we make a single choice or decision from among many different possible choices.

11. Next we DO SOMETHING about our decision. This means we TAKE ACTION in order to get something done.

12. Finally we COMPLETE the action. What started is now finished... ended...because there is nothing more to happen in that sequence.

13. Thus in any orderly sequence of happenings, there are DECISIONS, and there are ACTIONS that are COMPLETED.

14. Since these happenings are found in even the most complicated sequences, scientists and engineers can plan each step ahead of time so that each will happen in the right order at the right time.

15. They call their PLAN a FLOW CHART.

16. The FLOW CHART uses diamonds, squares, and circles as symbols to represent each kind of happening.

17. This symbol means that a DECISION will be made...Shall we do something? Our first step is to make a choice.

18. This symbol means that something will be DONE--the ACTION steps in a sequence. Go! Come! Wait! Go again! Return! Things are happening!

19. This symbol means that something will be COMPLETED. The last step in a sequence. We are FINISHED! The action is COMPLETED!

20. The FLOW CHART uses these symbols and connecting arrows to stand for the different parts of a sequence of happenings, because they show quickly what kinds of things are happening. DECIDING ...DOING...COMPLETING.

21. These symbols and arrows are put together to help in PLANNING each step of a SEQUENCE so everything will happen in ORDER and at the RIGHT time.

22. For example, we may want to go somewhere

23. We will begin by DECIDING to go...

24. Or not to go...

25. And if we go...

26. Then we must DECIDE when we will return...

27. Or to wait awhile...

28. And then return

29. When we return, we will stop...the trip will be completed.

30. The FLOW CHART permits us to PLAN each step in the RIGHT ORDER so that we can see what must happen.

31. Some happenings...like this...are so simple we can keep track of each step in our minds.

32. But other things that happen are so complicated...have so many steps...so many parts that must fit together...that we need a FLOW CHART to PLAN each step in the RIGHT ORDER.

33. And each step in the SEQUENCE also must be PLANNED to happen at just the RIGHT TIME.

34. Usually these things happen one step after the other...in SEQUENCE.

35. But sometimes they must happen ALL at the SAME TIME

36. ...SIMULTANEOUSLY

37. ...many things happening at once

38. because that is the way each step must fit together in order to come out right.

39. Each step is planned just so in our FLOW CHART showing exactly when each thing has to happen and when it must STOP.

40. Some DECISIONS mapped in the Flow Chart can be made right away...

41. But sometimes decisions cannot be made until there is more information...or until something else has happened.

42. Then we WAIT...often asking a question over and over again until we get an answer that will let us take the next step.

43. "Shall we do it?" "No," WAIT. Then again, "Shall we do it?" "No," WAIT. Over and over until we either STOP...or get the signal to go ahead.

44. So that's why the FLOW CHART is needed...to plan and decide on each thing to be done...

45. So no mistakes will be made...so things will happen in the right order.

(In this version there is no No. 46, 47, 48, 49, 50, and 51.)

52. The flow chart can also be used by other people to make things happen the SAME WAY over and over again. Because it is like a a map of what will be made to happen.

53. It uses a special language of diamonds, squares, circles, and arrows which represent what kind of action will take place... a decision...a doing of something...and a stopping.

54. So we have learned that we can make most things happen in an orderly step-by-step way...that each happening contains three different kinds of actions...and that we can make things happen the same way each time by PLANNING each step in sequence on a flow chart.

THE END

# APPENDIX B

## INSTRUCTIONS FOR FILM

### (Before the Film)

To Class: CAN YOU ALL SEE THE SCREEN?

(Move about as necessary, admonishing them to lean a little so they can see.)

YOU ARE ABOUT TO SEE A FILM ON A SUBJECT YOU HAVE NEVER STUDIED. IT WILL BE QUITE DIFFERENT FROM MOST FILMS YOU HAVE SEEN. THAT IS BECAUSE IT IS PART OF AN EXPERIMENT THAT IS BEING MADE BY SCIENTISTS. THEY ARE TRYING TO FIND OUT HOW TO MAKE BETTER TEACHING FILMS. AFTER THE FILM, YOU WILL BE GIVEN A TEST ON WHAT YOU SAW AND HEARD.

SO WATCH THE SCREEN AND PAY CLOSE ATTENTION. DO NOT TALK DURING THE FILM.

(Turn out lights and start film. Take sound level reading six feet in front of projector, making adjustments in level as necessary. Record time film began.

### (After the Film)

To Class: (Turn on lights and say:) ON YOUR WAY BACK TO THE ROOM, PLEASE STAY TOGETHER AND MOVE QUIETLY. WHEN YOU GET TO THE ROOM, LISTEN CAREFULLY TO THE MAN WHO WILL TELL YOU WHAT TO DO NEXT.

## TEST INSTRUCTIONS

### (Immediate Test)

If there is time before the group comes to the room, place a pencil and test booklet on each desk, record room temperature on the Group Data Sheet, and draw the following examples on the chalkboard.

1. Do you feel that the film you have just seen was

   a) very long.
   b) long.
   c) medium.
   d) short.
   e) very short.

2. Put an X on the line at the point you think best answers the question:

   a) How much did you like the film?

| | | |
|---|---|---|
| Disliked it very much | Just OK | Liked it very much |

Collect cards at the door, making certain they are all of the correct color.

When students have all arrived and are seated say:

To Class: DO NOT OPEN YOUR TEST UNTIL TOLD TO DO SO!

WRITE YOUR NAME, YOUR HOME ROOM TEACHER'S NAME, AND THE NAME OF YOUR SCHOOL ON THE COVER. (Pause)

IN THE UPPER RIGHT HAND CORNER OF THE TEST COVER, PUT THE LETTER _____. (Pause)

YOU HAVE JUST SEEN A FILM, AND NOW YOU ARE GOING TO TAKE A TEST ABOUT WHAT YOU SAW. IF YOU FOLLOW THE DIRECTIONS CAREFULLY AND DO THE BEST YOU CAN, YOU WILL BE HELPING SCIENTISTS IMPROVE EDUCATION IN OUR COUNTRY.

WHEN YOU TAKE THE TEST, READ EACH QUESTION CAREFULLY AND MAKE THE BEST ANSWER THAT YOU CAN. IF YOU CANNOT DECIDE ON AN ANSWER FOR ANY QUESTION, MAKE THE BEST GUESS YOU CAN AND GO ON TO THE NEXT QUESTION, AND THE NEXT UNTIL YOU COME TO THE WORD STOP AT THE END OF EACH SECTION.

THE TEST IS DIVIDED INTO FIVE PARTS. WHEN YOU HAVE FINISHED EACH PART OF THE TEST, WRITE DOWN THE TIME ON THE CLOCK, THEN STOP AND WAIT UNTIL I TELL YOU WHEN TO START THE NEXT PART.

NOW, TURN THE PAGE TO PART I PAGE I AND LET US LOOK AT THE FIRST QUESTION TOGETHER. (Pause)

(Start the stop watch. Write the time on the room clock into the space provided on the Group Data Sheet.)

To Class: QUESTION ONE SAYS:" DO YOU FEEL THAT THE MOVIE YOU HAVE JUST SEEN WAS: a) VERY LONG, b) LONG, c) MEDIUM, d) SHORT, or e) VERY SHORT. CIRCLE THE LETTER YOU BELIEVE BEST DESCRIBES HOW YOU FEEL."

(Demonstrate how to circle answer on first example on chalk board.)

DO THIS NOW, AND LOOK UP WHEN YOU HAVE FINISHED. (Pause)

NOW, READ QUESTION TWO TO YOURSELF AS I READ IT ALOUD: "DRAW A CIRCLE AROUND THE NUMBER OF MINUTES YOU THINK THE FILM LASTED." DO THIS NOW, AND LOOK UP WHEN YOU HAVE FINISHED. (Pause)

NOW, LET'S READ QUESTION THREE: "PUT AN X ON THE LINE AT THE POINT YOU THINK BEST ANSWERS THE QUESTION:

(Demonstrate using example on chalk board.)

IF YOU DIDN'T LIKE IT VERY MUCH, YOU WOULD PUT THE X DOWN AT THIS END...OR IF YOU LIKED IT A LOT. THEN YOU WOULD PUT THE X OVER AT THIS END...OR IF YOU THOUGHT IT WAS JUST OK, THEN YOU WOULD PUT THE X NEAR THE MIDDLE...OR THE X MIGHT GO ANYWHERE IN BETWEEN.

NOW, FINISH QUESTION THREE--IT CONTINUES ON PAGE TWO OF PART I--AND THEN GO ON AND ANSWER QUESTIONS FOUR, FIVE, SIX, AND SEVEN. WHEN YOU HAVE FINISHED, MARK DOWN THE TIME ON THE CLOCK AND STOP.

(At the end of seven (7) minutes by the stop watch, say:)

STOP! DO NOT TURN THE PAGE! BE SURE YOU MARK DOWN THE TIME YOU HAVE FINISHED. (Pause)

(Wait until you have their attention again--return hand on stop watch--and say:)

To Class: Part II
ARE WE ALL READY?

FOR MOST OF THE QUESTIONS IN THE NEXT PART, YOU SHOULD CIRCLE THE LETTER IN FRONT OF THE ANSWER YOU CHOOSE. OTHER QUESTIONS WILL ASK YOU TO DO OTHER THINGS. READ EACH QUESTION CAREFULLY AND MAKE THE BEST ANSWER YOU CAN. IF YOU CANNOT DECIDE ON AN ANSWER, MAKE A GUESS AND GO ON TO THE NEXT QUESTION. NOW, TURN THE PAGE AND BEGIN.

(Start the stop watch. Write down the time on the room clock. At the end of eight (8) minutes by the stop watch, say:)

STOP! DO NOT TURN THE PAGE. BE SURE YOU MARK DOWN THE TIME YOU FINISHED.

(Pause...return hand on stop watch.)

To Class: Part III
NOW, TURN THE PAGE AND DO PART III. READ EACH QUESTION CAREFULLY.

(Start stop watch, and mark down the time on the clock. At the end of twenty (20) minutes by the stop watch, say:)

STOP! DO NOT TURN THE PAGE. BE SURE YOU MARK DOWN THE TIME YOU FINISHED.

(Pause...return hand on stop watch.)

To Class: Part IV
NOW, TURN THE PAGE AND DO PART IV. BE SURE YOU READ EACH QUESTION CAREFULLY.

(Start stop watch, and mark down the time on the clock. At the end of twenty (20) minutes by the stop watch say:)

STOP! DO NOT TURN THE PAGE. BE SURE YOU MARK DOWN THE TIME YOU FINISHED.

(Pause, and return hand on stop watch.)

To Class: Part V
NOW TURN THE PAGE AND DO PART V. BE SURE YOU READ EACH QUESTION CAREFULLY.

(Start stop watch, mark down the time on the clock. At the end of eight (8) minutes by the stop watch, say:)

STOP! BE SURE YOU MARK DOWN THE TIME YOU FINISHED.

(Pause...return hand on stop watch.)

NOW, CLOSE YOUR BOOKLETS AND BE SURE YOUR NAME, YOUR TEACHER'S NAME, AND THE NAME OF YOUR SCHOOL ARE ALL WRITTEN ON THE FRONT. ALSO BE SURE THE LETTER ____ IS MARKED ON THE UPPER RIGHT HAND CORNER OF THE COVER. NOW, PASS THE BOOKLETS FORWARD TO THE FRONT OF THE ROOM.

WILL THE LAST PERSON IN EACH ROW COLLECT THE PENCILS IN HIS ROW AND PUT THEM IN THIS BOX.

(Pick up materials, then go on with oral discussion using questions below. Use other ideas as you wish, but try and include those below.)

To Class (tape recorded):

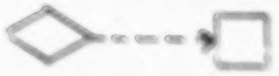
1. HAS ANYONE EVER SEEN A FILM LIKE THIS BEFORE? (hands and discussion)
2. HOW WAS THIS FILM DIFFERENT FROM OTHER FILMS YOU HAVE SEEN?
3. WHAT DID YOU LIKE ABOUT THE FILM?
4. WHAT DID YOU NOT LIKE ABOUT THE FILM?
5. HOW DO YOU THINK YOU MIGHT CHANGE THIS FILM TO MAKE IT EVEN BETTER?

(Put down temperature on data sheet.)

## SCORING KEY FOR FINAL TEST

Part I. (Do not score)

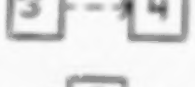
Part II. 1b, 2c, 3d, 4b, 5c, 6d, 7c, 8c, 9b, 10a, 11b, 12d, 13b,

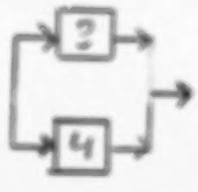
14 

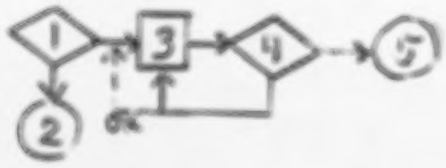
Part III. 1c, 2a, 3b, 4a, 5c, 6a, 7c, 8c, 9c, 10a, 11d, 12c, 13b, 14a,

15c, 16a, 17 Acceptable (typical)
Deciding to return home
Deciding when to return
Deciding to wait awhile
Deciding when to go home
Deciding it is time to go home
Deciding to go home

Not acceptable (typical)
Deciding to go
Coming back
Starting
What should we do?
Deciding whether to go or not
Starting home
Diamond
Deciding

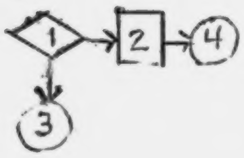
18 1 point 

2 points 

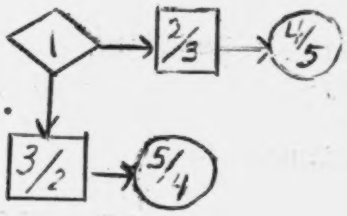
19 b 20 

21 a

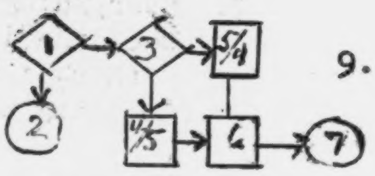
**Part IV.** 1b, 2b, 3c, 4. 5. 2&3 6.



7.

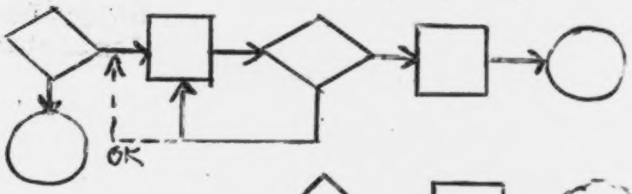


8.

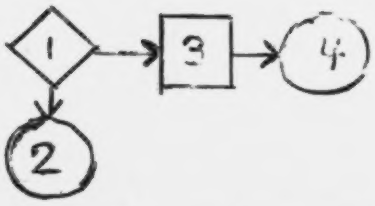


9. Yes No
Yes No
Yes No

10.

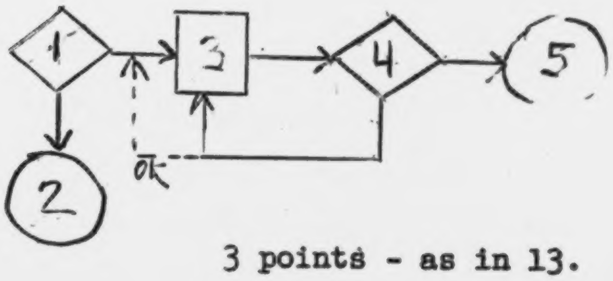


11a 12c 13.



1 point for correct symbols
1 point for correct number of arrows
1 point for correct configuration

14.



3 points - as in 13.

**Part V.** 1c 2b 3a 4d 5c 6d 7d

8.

| Acceptable (typical) | Not acceptable (typical) |
|---|---|
| 1. Deciding to launch<br>Deciding whether to launch | Deciding<br>Starting launch |
| 2. Not launching<br>Not launch | Stopping ending<br>Completing |

| | | |
|---|---|---|
| 3-6. | Put on space suit<br>Engine fueled<br>Rocket checked<br>Tracking stations ready | Doing something<br>Doing<br>Ready |
| 7. | Everything ready?<br>Deciding if everything is ready<br>Deciding to continue | Deciding |
| 9. | Launching part of trip completed<br>Launch ended | Recovery complete<br>Man is recovered<br>Landing<br>Stopping<br>Completing |

DO NOT BEGIN
Until Told
To Do So

Name ____________________
Teacher ______________________
School ______________________

1. Do you feel that the movie you have just seen was

   a) very long.
   b) long.
   c) medium
   d) short.
   e) very short.

2. Draw a circle around the number of minutes you think the film lasted:

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

3. Put an X on the line at the point you think best answers the question:

   a) How much did you like the film?

| | | |
|---|---|---|
| Disliked it very much | Just OK | Liked it very much |

   b) How much do you think you learned from the film?

| | | |
|---|---|---|
| Learned very little | Just OK | Learned very much |

   c) How well could you understand the man talking?

| | | |
|---|---|---|
| Could not understand | OK | Very well |

   d) How fast did the man talk?

| | | |
|---|---|---|
| Very slow | Just right | Very fast |

e) How many pictures were there?

| | | |
|---|---|---|
| Not enough | Just right | Too many |

f) How fast do you think things happened in the film?

| | | |
|---|---|---|
| Too slow | Just right | Too fast |

g) How do you think the pictures went with what the man said?

| | | |
|---|---|---|
| Very bad | Just right | Very good |

4. In the film there were times when there were no pictures on the screen. What did the screen look like then?

5. Which part of the film did you like best?

6. Which part of the film did you like least?

7. Had you ever seen a flow diagram before you saw this film?

   a) Yes
   b) No

********************

When finished, mark down the time on the clock: ________________.

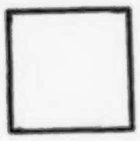
STOP!

DO NOT TURN THE PAGE UNTIL TOLD TO DO SO!

1. When the steps of a process follow each other in order, we say there is

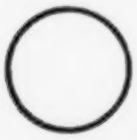
   a) a complicated problem.
   b) a sequence of happenings.
   c) a rocket launching.
   d) a flow chart.

2. What is the meaning of this symbol?



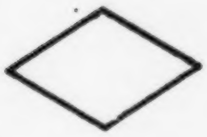
   a) A sequence of happenings is starting.
   b) Something has been completed.
   c) Something is being done.
   d) A decision is being made.

3. What is the meaning of this symbol?



   a) A sequence of happenings is starting.
   b) Something is being done.
   c) A decision is being made.
   d) A sequence of happenings is finished.

4. What is the meaning of this symbol?



   a) A sequence of happenings is finished.
   b) A decision is being made.
   c) Something is being done.
   d) Something has been completed.

5. What three kinds of things take place in any sequence of happenings?

   a) choosing, preparing and eating
   b) diamonds, circles and squares
   c) doing, deciding and completing

6. In a flow chart, what shows the order in which things happen?

   a) diamonds
   b) circles
   c) squares
   d) arrows

7. The symbol with which any sequence of happenings always stops is

a) a diamond.
b) a square.
c) a circle.
d) an arrow.
e) it is not possible to say.

8. In a flow chart how many arrows can go out of a diamond?

a) none
b) one
c) two
d) any number

9. In a flow chart how many arrows can go out of a square?

a) none
b) one
c) two
d) any number

10. In a flow chart, how many arrows can go out of a circle?

a) none
b) one
c) two
d) any number

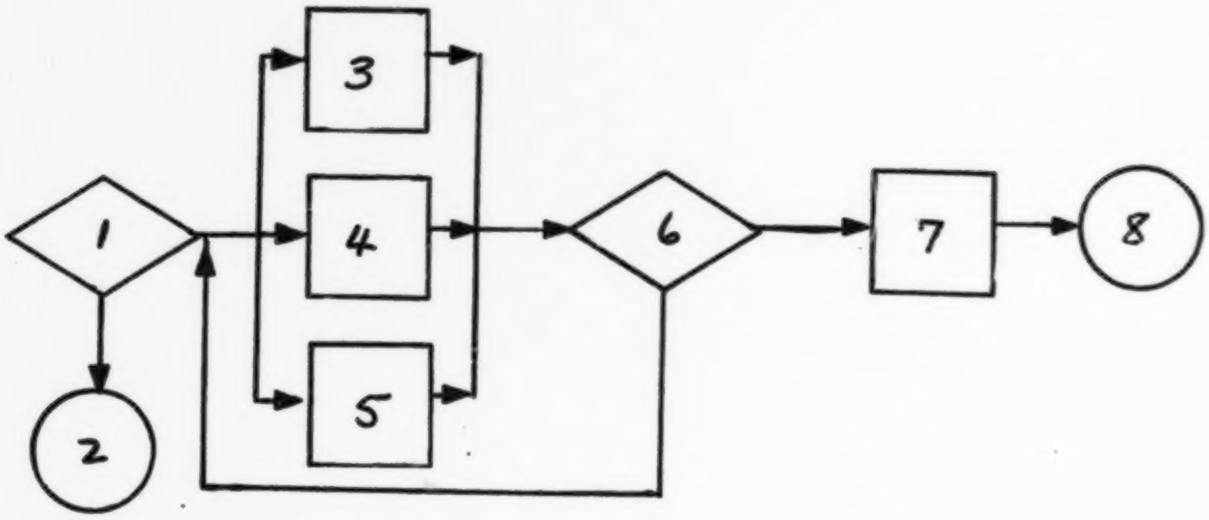
11. If two arrows go out of a flow chart symbol, you can tell that

a) the symbol is a square.
b) a decision is to be made.
c) a sequence of happenings is beginning.
d) a sequence of happenings has ended.

12. In a flow chart, a circle means a sequence of happenings is completed. Therefore,

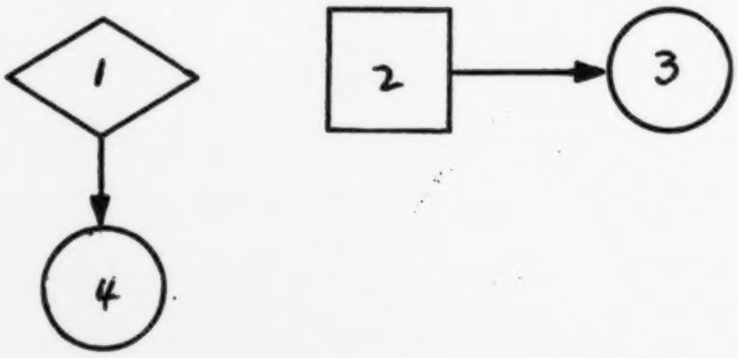
a) two arrows always go into the circle.
b) there are arrows missing.
c) no arrows can go into a circle.
d) no arrows can go out of a circle.

13. **What events in this sequence of happenings take place at the same time?**



a) 1, 2, 3
b) 3, 4, 5
c) 1, 6
d) 6, 7, 8

14. **Fill in the missing part of this flow chart:**



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**When finished, mark down the time on the clock: _______________.**

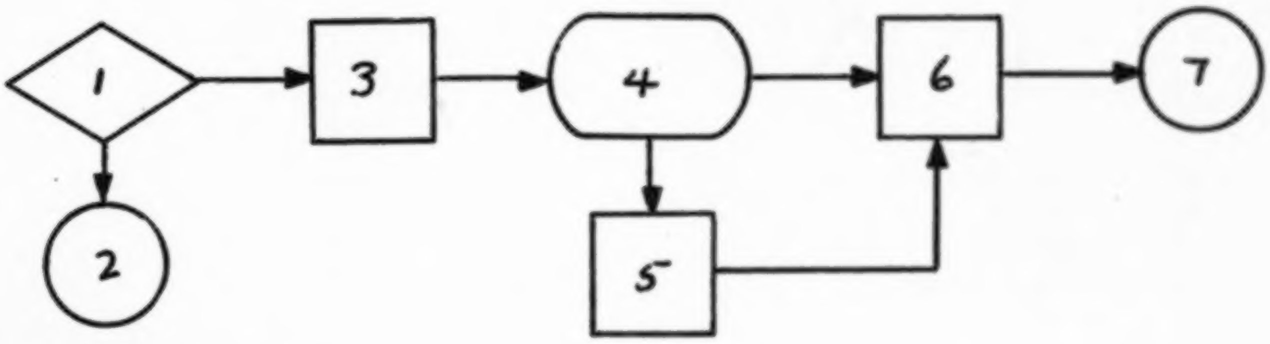
**STOP!**

**DO NOT TURN THE PAGE UNTIL TOLD TO DO SO!**

1. When we use a cookbook recipe for making cookies, the recipe tells us how to:

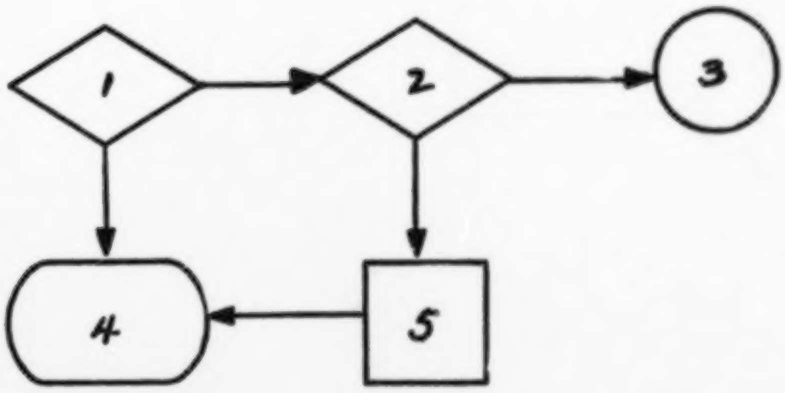
   a) make a flow chart.
   b) make cooking complicated and difficult.
   c) mix in the right things at the right time.

2. In the flow chart below, symbol 4 is wrong. What should it be?



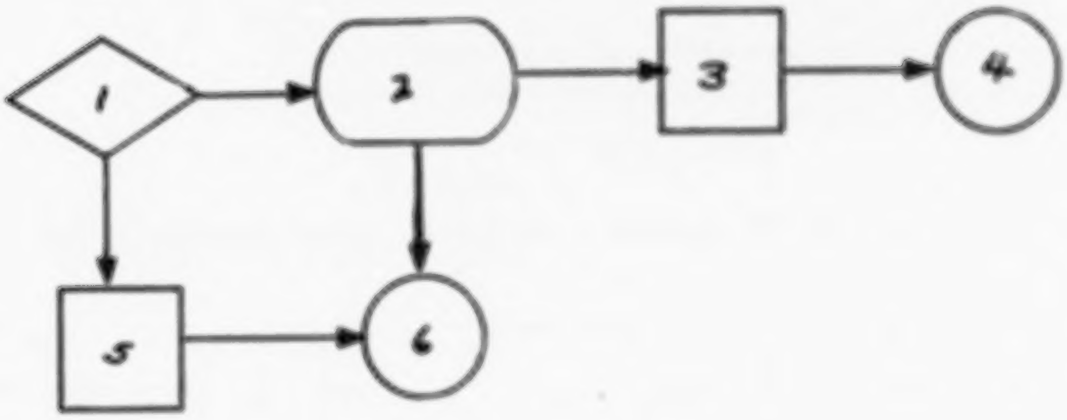
   a) a diamond
   b) a circle
   c) a square
   d) none of these

3. In the flow chart below, symbol 4 is wrong. What should it be?



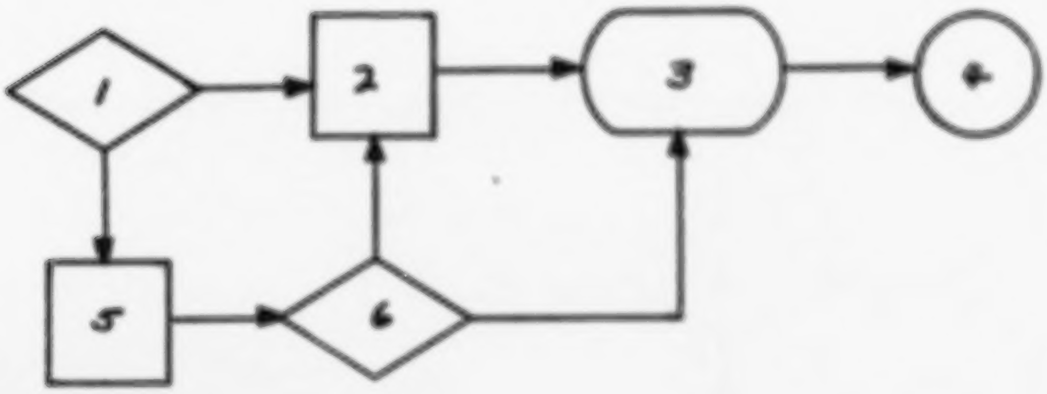
   a) a diamond
   b) a circle
   c) a square
   d) none of these

4. In the flow chart below, symbol 2 is wrong. What should it be?



a) a diamond
b) a circle
c) a square
d) none of these.

5. In the flow chart below, symbol 3 is wrong. What should it be?



a) a diamond
b) a circle
c) a square
d) none of these

6. Which of the following could not be represented by a flow chart?

a) an airplane
b) going on an airplane trip
c) making a model airplane

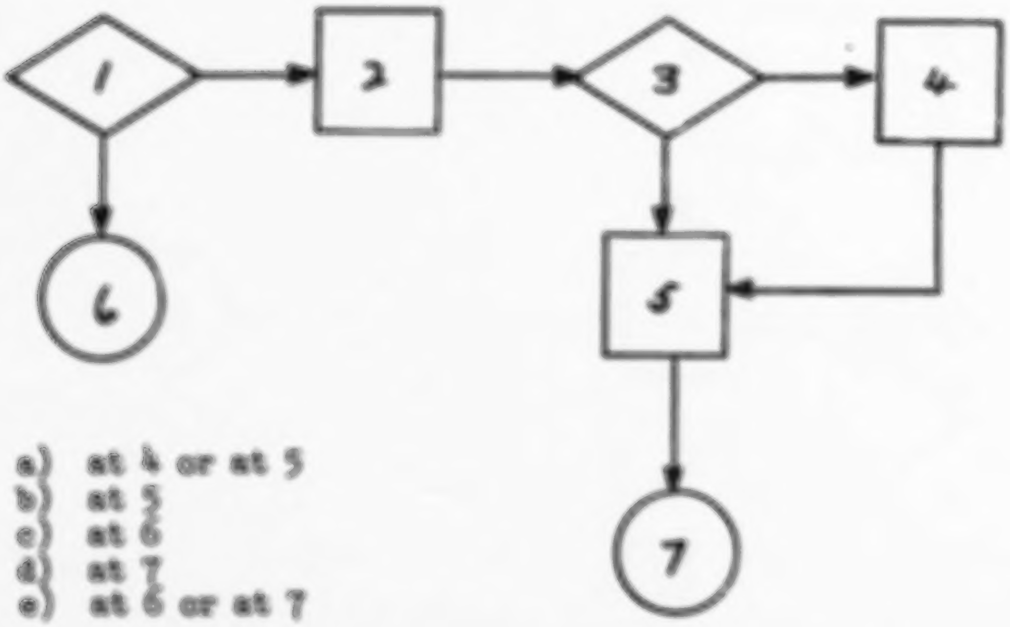
7. How does a flow chart help us avoid errors?

   a) It makes decisions for us.
   b) It faces us with complicated problems.
   c) It helps us check each step in an orderly way.
   d) It uses circles, diamonds and squares.

8. To solve complicated problems, we have to

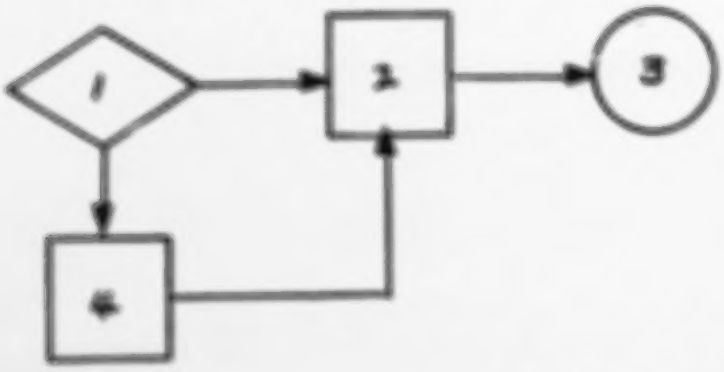
   a) use diamonds, circles and squares.
   b) make things happen very quickly.
   c) make things happen in a step-by-step order.

9. Where will this sequence of happenings end?



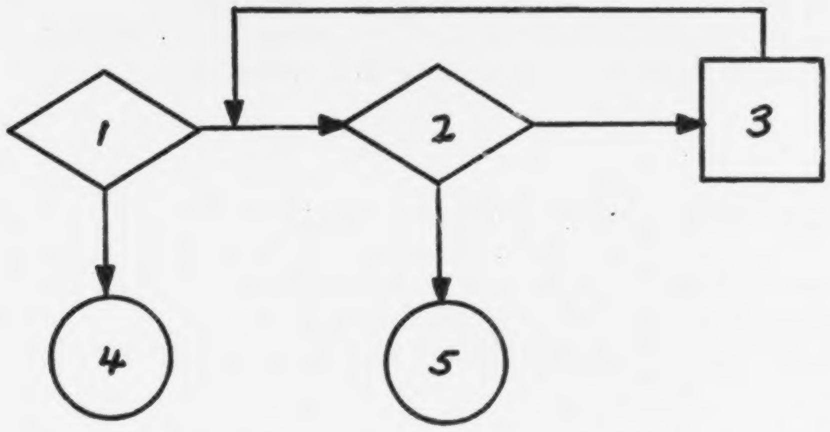
   a) at 4 or at 5
   b) at 5
   c) at 6
   d) at 7
   e) at 6 or at 7

10. In this sequence of happenings, how many times will event 2 happen?



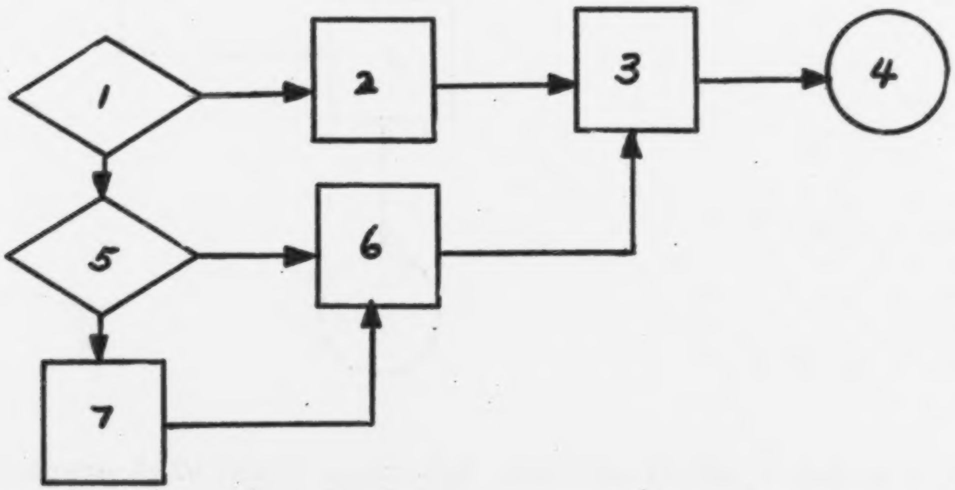
   a) once
   b) twice
   c) four times
   d) it is not possible to say

11. In this sequence of happenings, how many times will event number 3 happen?



a) once
b) twice
c) three times
d) it is not possible to say

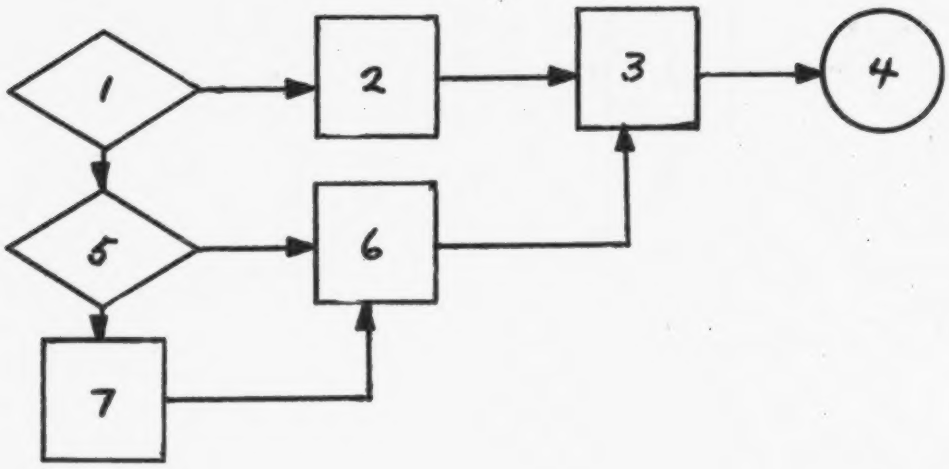
12. Look at this flow chart.



What happening comes after number 6?

a) 1
b) 2
c) 3
d) 5
e) 7

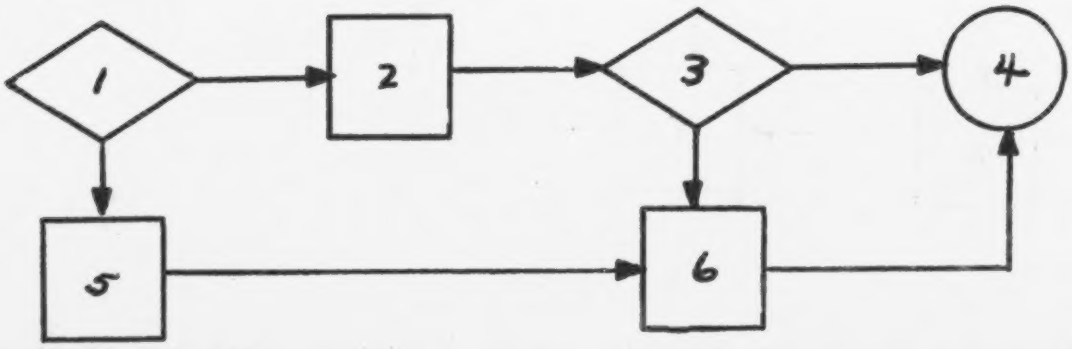
13. Look at this flow chart.



Symbol number 1 is a decision. Different paths will be taken in the flow chart depending upon the decision at symbol number 1. What happening will always occur no matter what choice is made at symbol 1?

a) 2
b) 3
c) 5
d) 6
e) 7

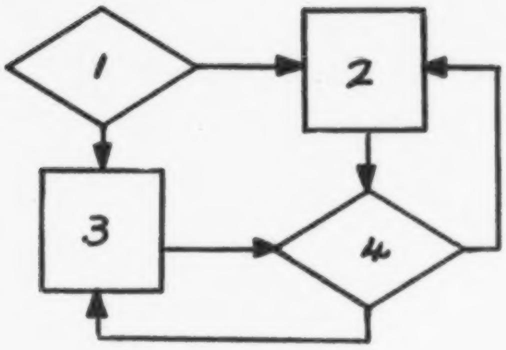
14. Look at this flow chart.



If the happening shown in box 5 occurs, what other events have already occurred?

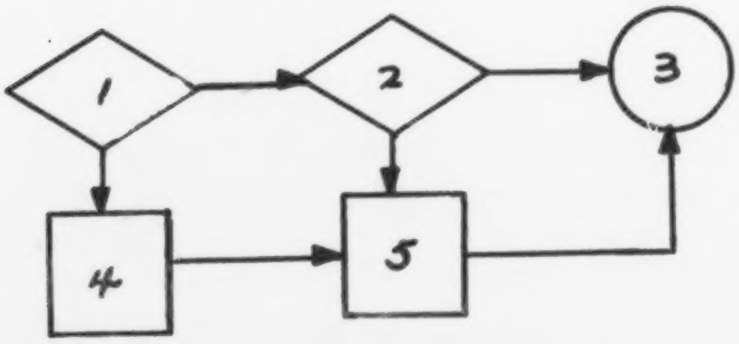
a) 1
b) 1, 2, and 3
c) 3, 4, and 6
d) no other events have occurred

15. Where will this sequence of happenings be completed?



a) in box 1
b) in box 2
c) in box 3
d) in box 4
e) it will never be completed

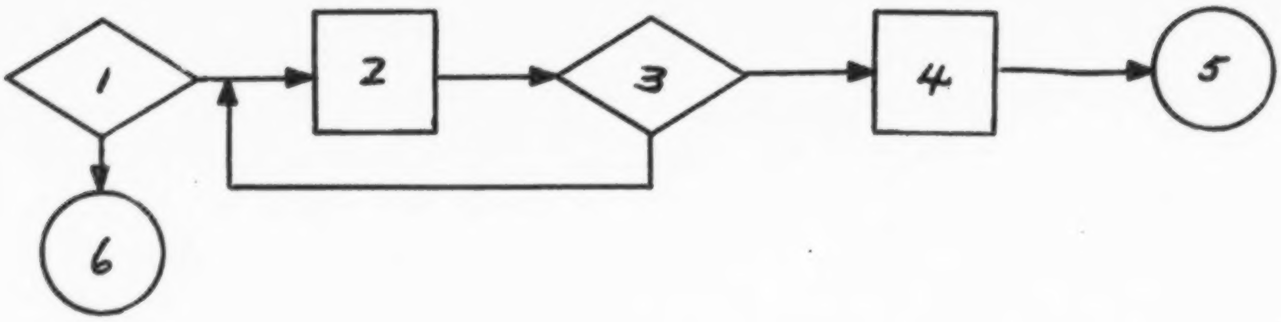
16. Look at this flow chart.



After the happening shown by symbol 4 occurs, what two other events cannot occur?

a) 1 and 2
b) 2 and 3
c) 3 and 5

17. Here is a flow chart for going on an automobile ride.



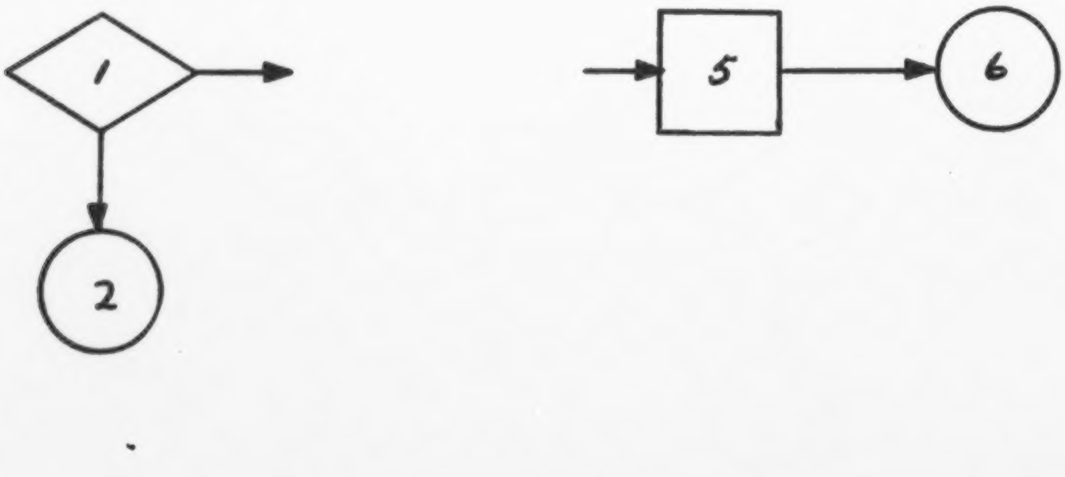
Symbol 1 is "deciding whether to go or not."
Symbol 2 is "riding."
Symbol 4 is "returning home."
Symbol 5 is "the ride is completed."
Symbol 6 is "not going."

Question: What is symbol 3? Answer: ______________________________.

18. Here is a sequence of happenings:

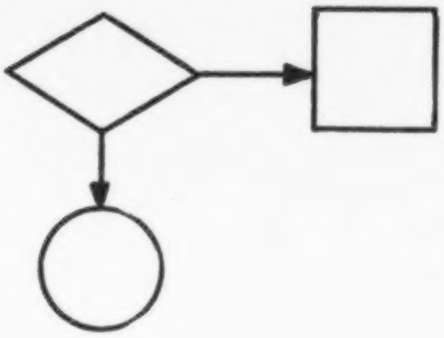
First we decide whether or not to eat soup (1).
If we decide "no," we do not eat soup (2).
If we decide "yes," then we do two things at the same time: we heat the soup (3),
and while it is heating, we set the table (4).
Then we eat the soup (5).
Finally, we finish (6).

Here is part of the flow chart for this sequence of happenings. Fill in and number the missing symbols.

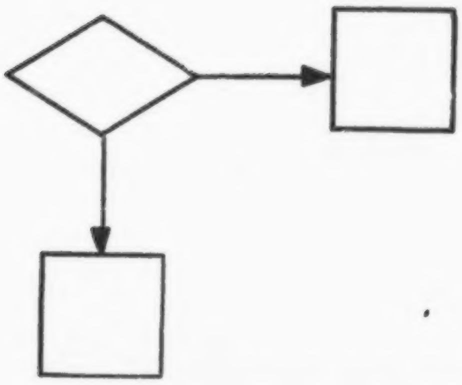


19. How would this statement be shown as part of a flow chart:
"If you have more than 10¢, buy the magazine; otherwise buy the candy."

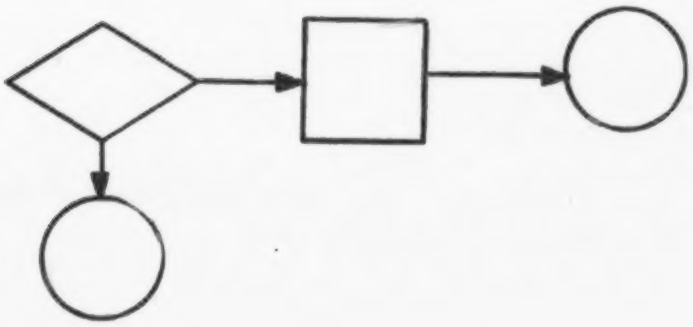
a)



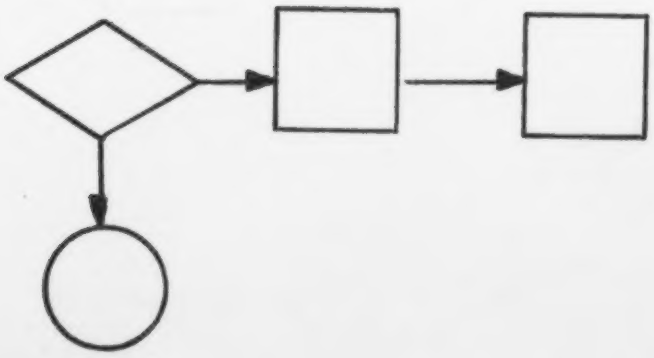
b)



c)

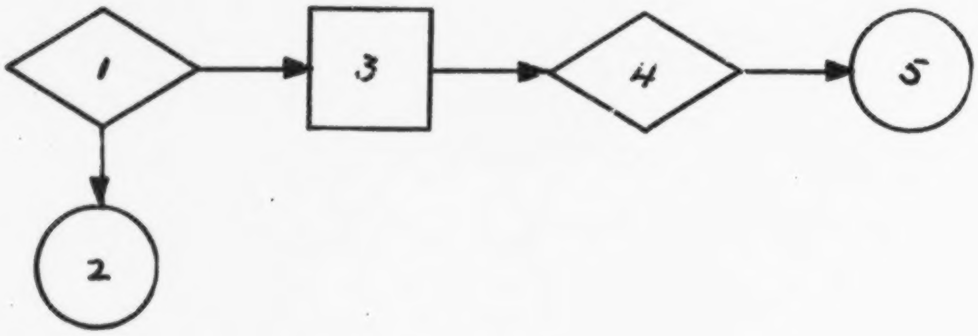


d)



20. Here is a sequence of happenings and its flow chart. An arrow is missing. Draw the arrow where it should be.

    1. Deciding to go shopping.
    2. Not going.
    3. Buying something.
    4. Deciding if everything needed has been bought.
    5. Finishing.



21. Read this sentence: "If I have enough money, I will go to the movies." In a flow chart how would you draw the part of the sentence that is underlined?

    a) as a diamond
    b) as a square
    c) as a circle
    d) as an arrow

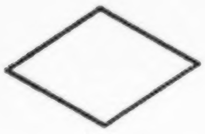
********************

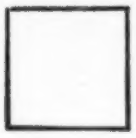
When finished, mark down the time on the clock: _______________.

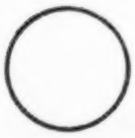
STOP!

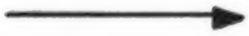
DO NOT TURN THE PAGE UNTIL TOLD TO DO SO!

1. In a flow chart for getting dressed in the morning, what symbol would be used to indicate that you had finished dressing?

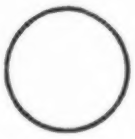
a) 

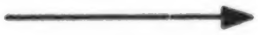
c) 

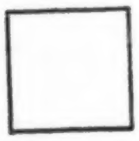
b) 

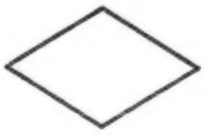
d) 

2. In a flow chart for getting dressed in the morning, what symbol would be used for putting your shoes on?

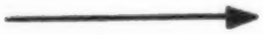
a) 

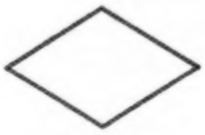
c) 

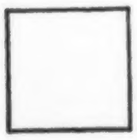
b) 

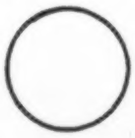
d) 

3. In a flow chart for getting dressed in the morning, what symbol would be used for deciding whether or not to wear a sweater?

a) 

c) 

b) 

d) 

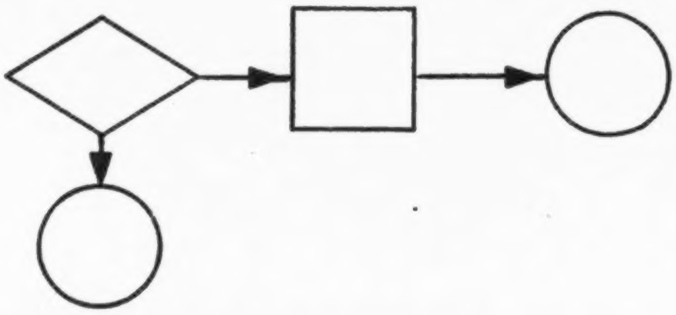
4. What is the correct flow chart symbol for each of the events below? Next to each event draw the correct flow chart symbol.

1. Sleeping:
2. Deciding whether or not it is time to get up:
3. Walking to school:
4. Getting up:
5. Brushing your teeth:
6. Deciding whether to have cereal or eggs:

5. In the following sequence of happenings, draw a circle around the two events that could happen at the same time:

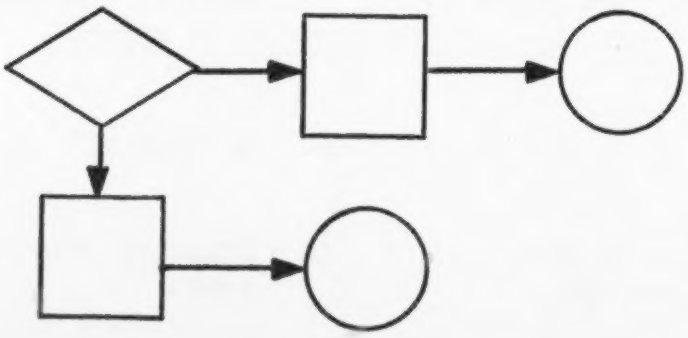
    1. Filling a pan with water.
    2. Putting the pan on the stove.
    3. Turning the fire on.
    4. Deciding whether or not the water is boiling.
    5. Turning the fire off.

6. Below are a flow chart and a list of happenings. Match the happenings with the flow chart symbols. Write the number of each happening in the proper flow chart symbol.



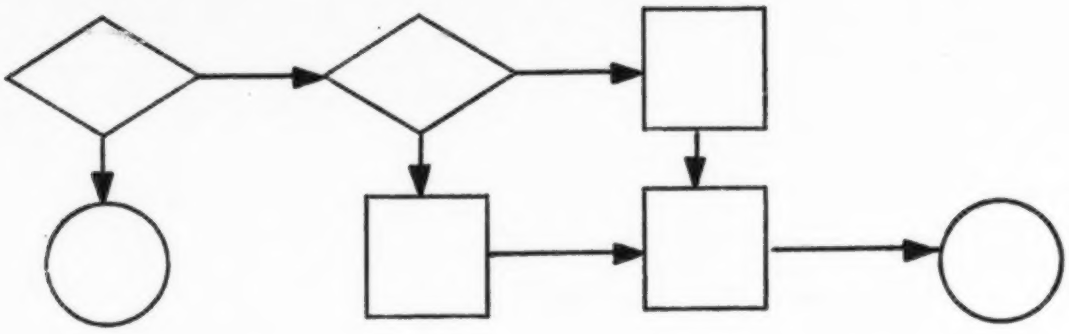
    1. Deciding whether to go for a walk or not.
    2. Going for a walk.
    3. Not going for a walk.
    4. Finishing the walk.

7. Below are a flow chart and a list of happenings. Match the happenings with the flow chart symbols. Write the number of each happening in the proper flow chart symbol.



    1. Deciding whether to read a book or watch TV.
    2. Watching TV.
    3. Reading a book.
    4. Finishing watching TV.
    5. Finishing reading.

8. Below are a flow chart and a list of happenings. Match the happenings with the flow chart symbols. Write the number of each happening in the proper flow chart symbol.

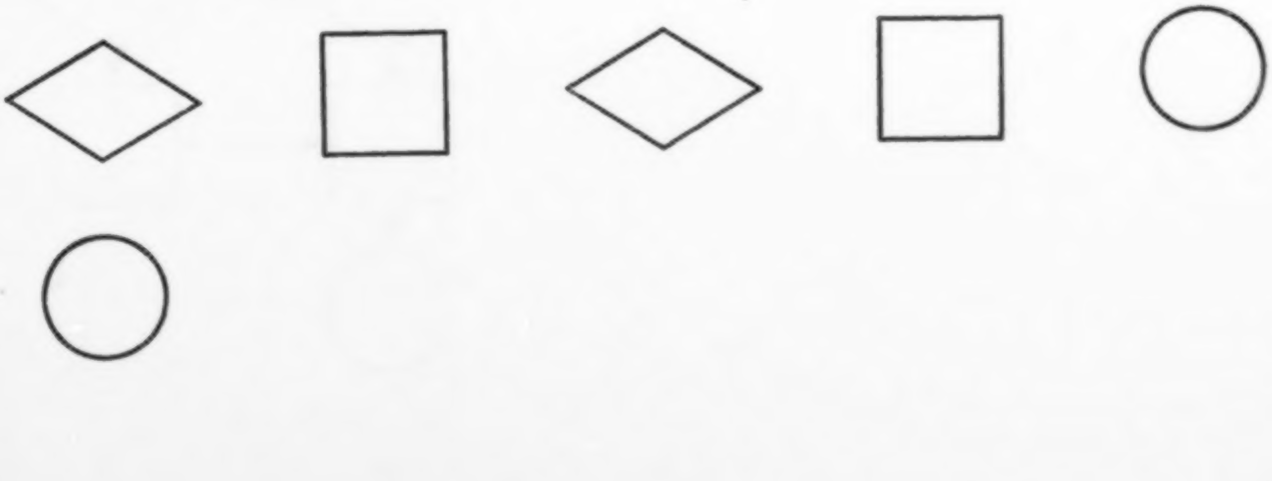


1. Deciding whether or not to eat.
2. Not eating.
3. Deciding whether to eat cereal or eggs.
4. Eating cereal.
5. Eating eggs.
6. Washing the dishes.
7. Finishing.

9. Some of the things listed below could be represented by a flow chart and some could not. Write yes beside those which could be represented by a flow chart, and no beside those which could not.

___ 1. Writing a letter to a friend.
___ 2. Making a model automobile.
___ 3. Taking a test.
___ 4. An automobile.
___ 5. The principal of your school.
___ 6. A road map.

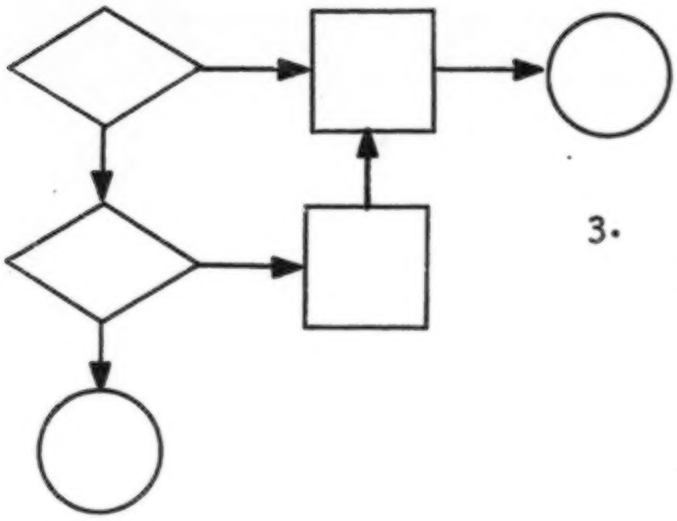
10. Here is part of a flow chart for going on an automobile ride. Put in the missing arrows.



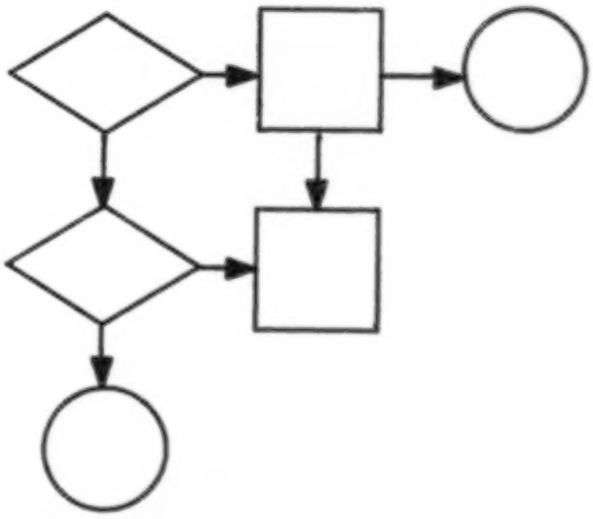
11. Which of the flow charts below could represent the same sequence of happenings?

a) 1 and 2
b) 1 and 3
c) 2 and 3
d) 2 and 4

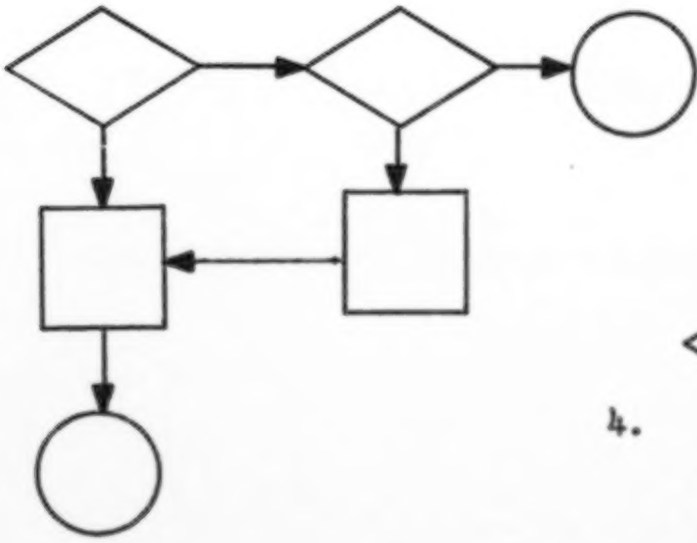
1.



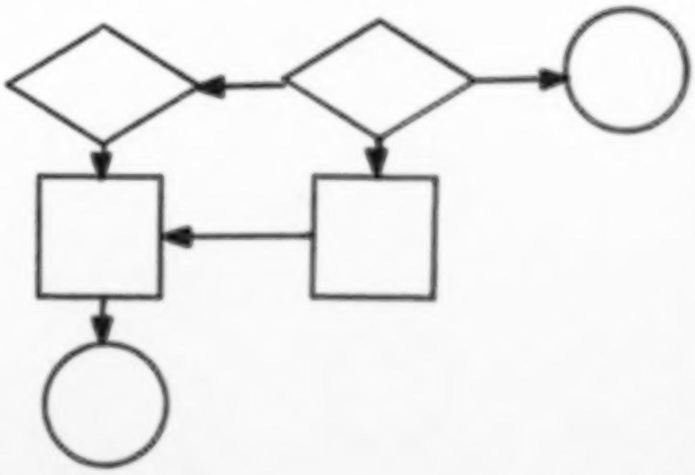
3.



2.



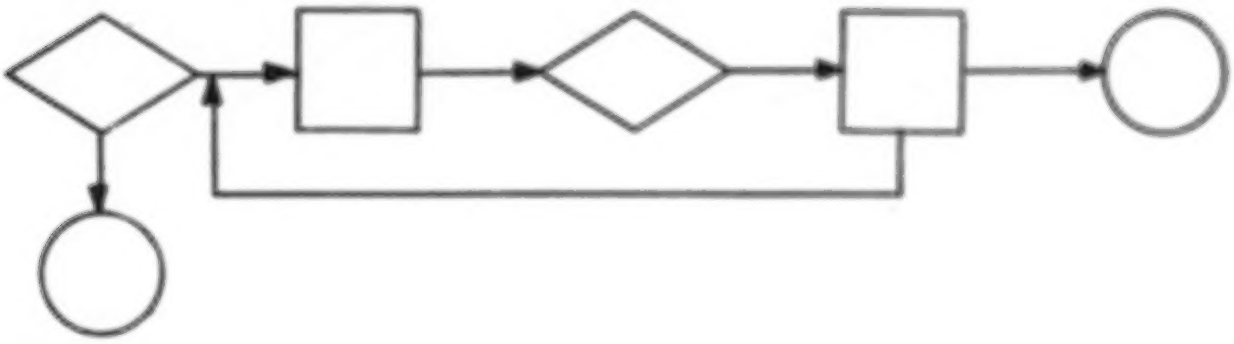
4.



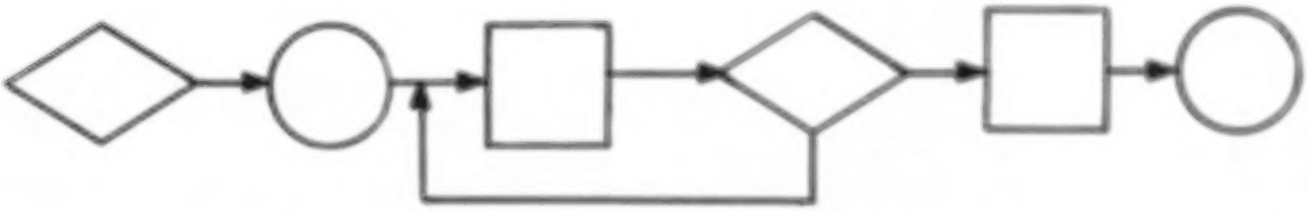
12. Which flow chart below represents the following story?

John decides whether or not to go for a walk.
If he decides not to, he does not go.
If he decides to go, he walks for a while.
Then he must decide if it is time to go home.
If it is not time to go home, he walks some more.
If it is time to go home, he walks home.
His walk is finished.

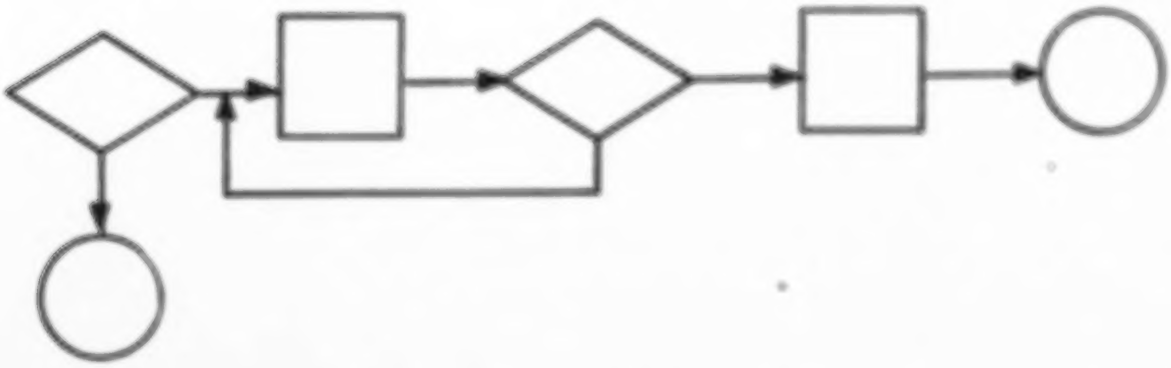
a)



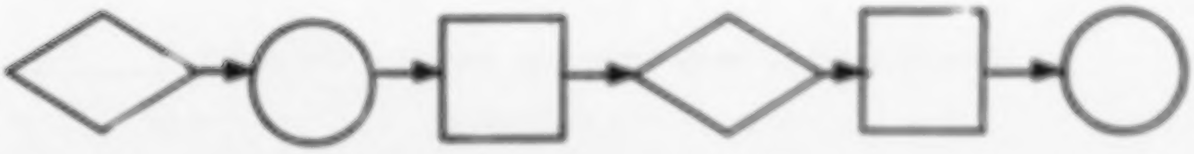
b)



c)



d)



13. Here is the sequence of happenings for reading a story:

    1. Deciding whether or not to read the story. (Deciding)
    2. Not reading the story. (Completing)
    3. Reading the story. (Doing)
    4. Finishing the story. (Completing)

    Draw a flow chart for this sequence of happenings and mark each symbol with the number of the happening it represents.

14. Here is a sequence of happenings for writing a letter to a friend. Make a flow chart for writing the letter according to the steps below. Label each symbol with the number of the happening.

    1. First we decide whether or not to write. (DECIDING)
    2. If no, we do not write the letter. We stop. (COMPLETING)
    3. If yes, we write. (DOING)
    4. We then decide if we have written all we want to write. (DECIDING) If we have more to write, we go back to writing (3, DOING).
    5. If we have no more to write, we stop (COMPLETING) and write no more.

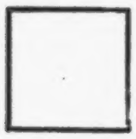
**********************

When finished, mark down the time on the clock: ______________.

STOP!

DO NOT TURN THE PAGE UNTIL TOLD TO
DO SO!

1. This symbol could be used to represent



   a) deciding whether or not to launch a space rocket.
   b) the completion of a space trip.
   c) putting a space suit on an astronaut.
   d) none of these.

2. Recovery teams guide the capsule out of orbit and back toward earth.

   a) True
   b) False

3. How are computers used in a rocket launching?

   a) They determine when and where the capsule should leave orbit.
   b) They rescue the astronaut from the ocean.
   c) They report the readiness of the tracking stations.
   d) They fuel the rocket engine.

4. What happens in a rocket launching sequence if the tracking stations are not ready?

   a) Radars determine the orbit of the space capsule.
   b) The final signal to blast off is given.
   c) The astronaut does not put on his space suit.
   d) There is a wait while the problem is corrected.

5. What part do recovery teams play in an astronaut's trip?

   a) They give the signal to blast off.
   b) They determine the right time and place to leave orbit.
   c) They rescue the astronaut from the ocean.
   d) They release recovery parachutes.

6. What happens when it is time for the space capsule to leave orbit?

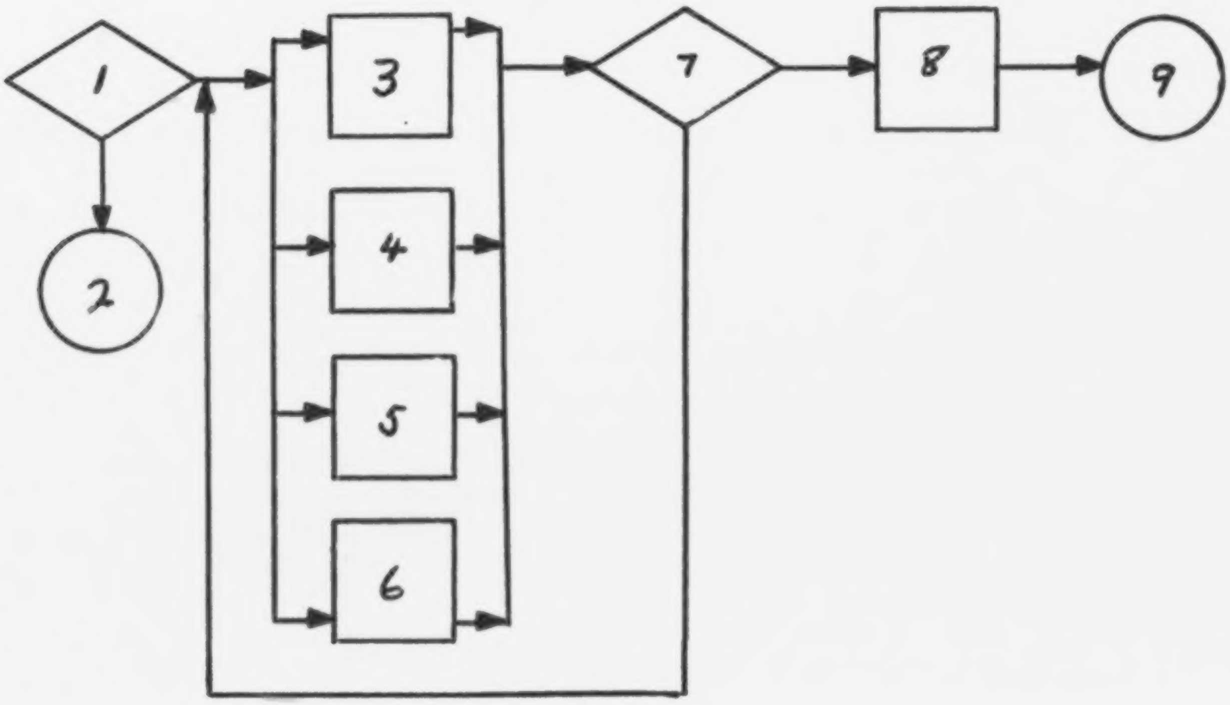
   a) Scientists and engineers make a new flow chart.
   b) Recovery teams rescue the astronaut from the ocean.
   c) A Decision is made whether or not to launch the rocket.
   d) The return rockets are fired.

7. Which of these things happen while a rocket engine is being fueled?

1. Different parts of the rocket are checked.
2. The astronaut puts on his space suit.
3. Radar tracking stations report readiness.
4. Computers determine the time to leave orbit.

a) 1 and 3
b) 1 and 4
c) 2 and 3
d) 1, 2, and 3
e) 1, 2, 3, and 4

8. Here is the flow chart for the launching sequence of the astronaut's trip into space. The square marked 8 represents blast off. What do the other symbols represent?



1 ____________________  5 ____________________
2 ____________________  6 ____________________
3 ____________________  7 ____________________
4 ____________________  9 ____________________

********************

When finished, mark down the time on the clock:__________.

THANK YOU

# APPENDIX C

## COEFFICIENTS OF STABILITY: BY GRADE AND FILM

## (RELIABILITY OF FINAL TEST MEASUREMENTS)

| FILM GROUP | GRADE | | | |
|---|---|---|---|---|
| | 6 | | 8 | |
| | II-IV | II-V | II-IV | II-V |
| 1 | .83 | .84 | .85 | .88 |
| 2 | .87 | .87 | .85 | .86 |
| 3 | .89 | .90 | .90 | .89 |
| 4 | .86 | .85 | .86 | .86 |
| 5 | .87 | .88 | .88 | .85 |
| 6 | .83 | .82 | .88 | .89 |

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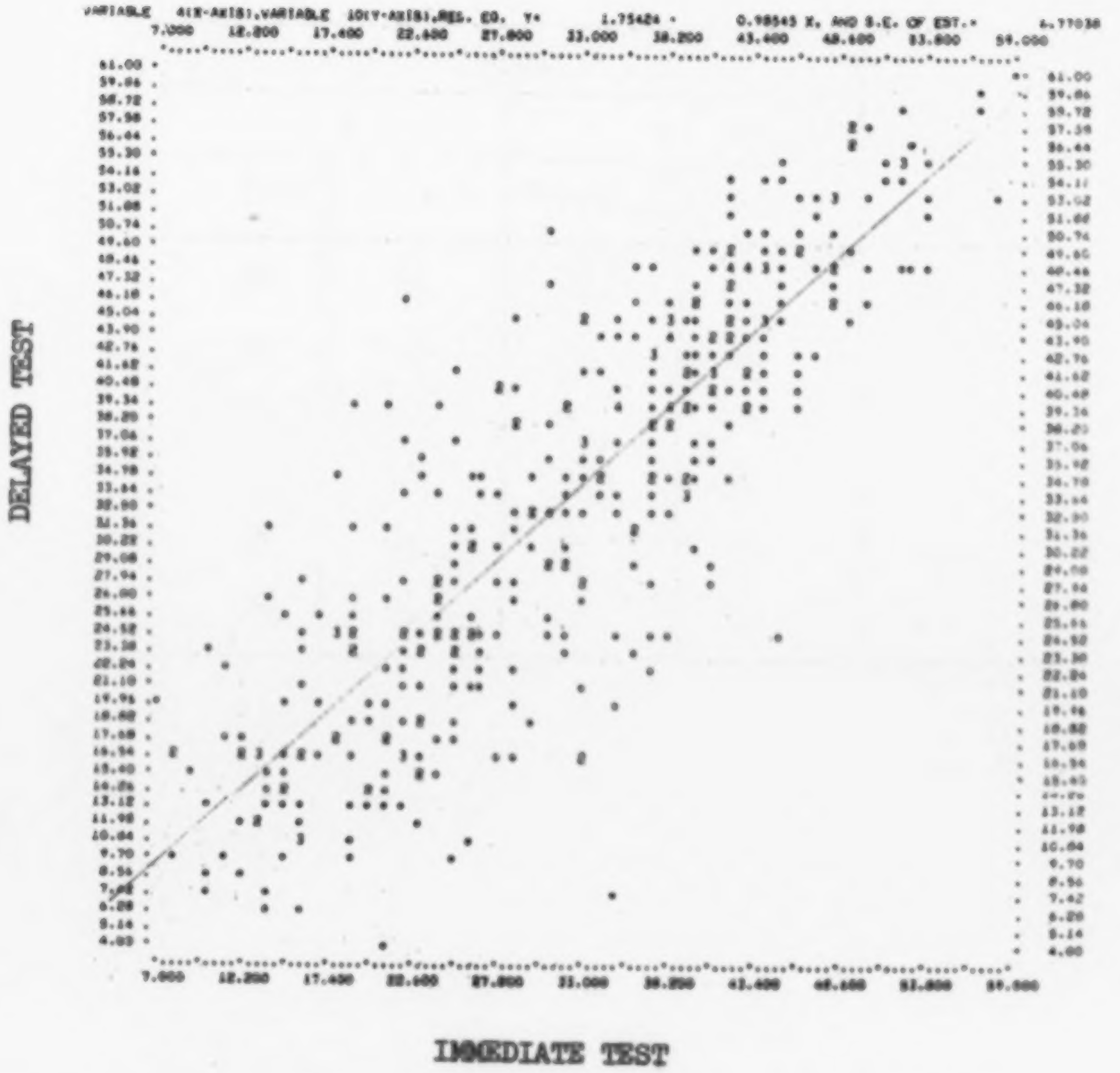
# APPENDIX C

## COEFFICIENTS OF STABILITY: BY GRADE AND FILM

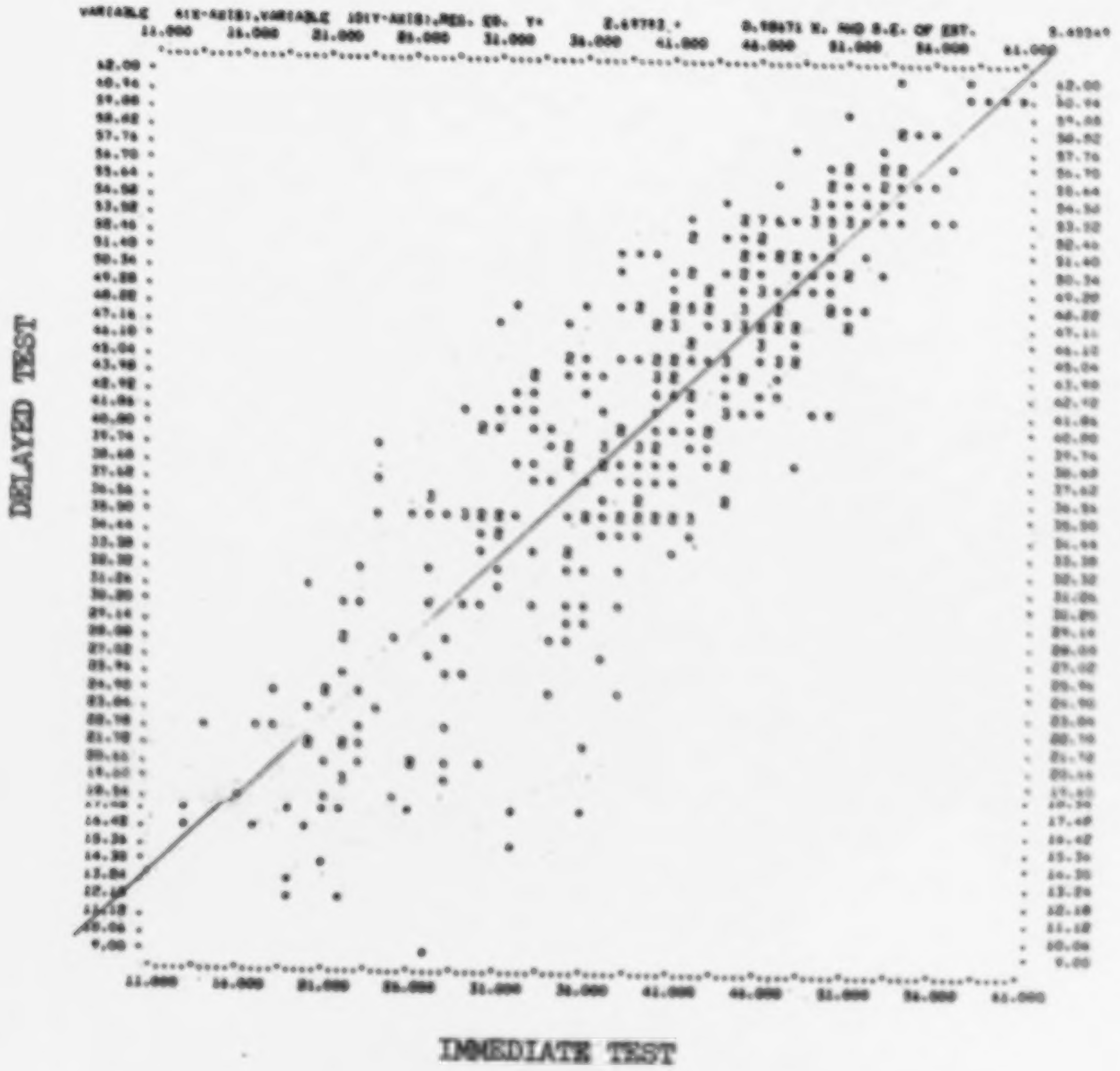
## (RELIABILITY OF FINAL TEST MEASUREMENTS)

| FILM GROUP | GRADE | | | |
|---|---|---|---|---|
| | 6 | | 8 | |
| | II-IV | II-V | II-IV | II-V |
| 1 | .83 | .84 | .85 | .88 |
| 2 | .87 | .87 | .85 | .86 |
| 3 | .89 | .90 | .90 | .89 |
| 4 | .86 | .85 | .86 | .86 |
| 5 | .87 | .88 | .88 | .85 |
| 6 | .83 | .82 | .88 | .89 |



SCATTER PLOTS OF INTERCORRELATION BETWEEN TOTAL SCORES (PARTS II-IV) OF THE IMMEDIATE AND DELAYED TESTS (N=462), SIXTH GRADE.

(Line is fitted by estimate.)



SCATTER PLOTS OF INTERCORRELATION BETWEEN TOTAL SCORES (PARTS II-III) OF THE IMMEDIATE AND DELAYED TESTS (N=439), EIGHTH GRADE.

(Line is fitted by estimate.)